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IRON ARCHES.

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From "Engineering."

The practical theory of arches has probably made less progress than any other branch of engineering knowledge. There are in common use two forms of arch, entirely distinct in their mechanical arrangement and source of strength, viz., the voussoir arch built of separate stones, and the continuous arch of wood or iron. The first of these has, indeed, received much attention from mathematicians, but from the unsatisfactory and indeterminate character of the problem of the arch, when the friction between the stones is considered, the theory has in general been confined to the various forms of equilibrated arches, which stand in virtue of the adjustment of the loads on each voussoir, without calling into play any friction forces between the voussoirs. It is, however, manifest that, for a heavy movable load, such as almost all arches are liable to, any theory of the arch which neglects friction is very far from complete, and such is the power of this friction to secure the stones of an arch, that in practice the theoretical forms are rarely considered, and the shape of the arch is decided upon in accordance with points of appearance or convenience. The friction, indeed, never reaches its limit in practice, and arches fail, not by the voussoirs slipping upon one another, but by the resultant line of thrust falling too near to the outside of the arch. Since, then, the friction never reaches its limit, it is impossible to say what its value may be for a given disposition of load, and hence the indeterminate nature of the problem, as will be pointed out hereafter.

For the continuous arch there is, so far as the writer is aware, no published investigation of a practical character. This form of arch is mainly due to the rapid progress of construction in wrought iron, and from its strength and security it has become the favorite form of arch for bridges of large span. It is, therefore, of great importance to investigate, however approximately, the strains on such arches, and there is less difficulty and uncertainty in doing so for a continuous arch of wrought iron than for a voussoir arch, because in general the depth of the ribs of a continous arch is small compared with the radius of the arch, and this circumstance offers great facilities for approximation. The main object of the present communication is to investigate the strains on a continuous iron arch.

It will, however, be proper, first, to examine into the conditions of equilibrium of a voussoir arch, in order to show the indeterminate character of the problem, as also to point out the different nature of the forces which the two forms of arch are able to bring into play to resist rup-

ture, and on which they rely for their stability. This may be done shortly, as follows:

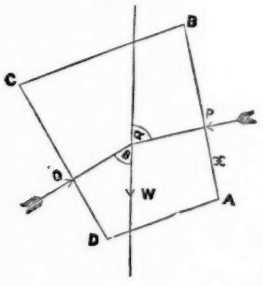
Consideration of an equilibrated arch, i.e., an arch constructed of voussoirs whose weights are so adjusted that every voussoir is in equilibrium without calling into action any force or friction between adjacent voussoirs.

(It will be found proved in works on mechanics that this will be the case when the weights of the voussoirs are proportional to the difference of the tangents of the angles which their joints make with the vertical.)

In this case there will be no forces acting at the joints of a voussoir, but the pressures of the adjacent voussoirs; these will all be normal to the joints at which they act, and the resultant of such forces at each joint will, therefore, also be normal to the joint.

Let, then, A, B, C, D, Fig. 1, be a stone

[FIG. 1.



of an equilibrated arch. This stone is in equilibrium under the action of three forces, viz.: The pressures at the joints collected into their resultants, P and Q, and the weight, W, of the stone. These three forces must, therefore, meet in a point in the vertical through the centre of gravity of the stone, as shown in the figure, and since the position of the stone is supposed known, the angles a and β, which the directions of the side forces make with the vertical, are also known. The force P will be known in terms of the weights of the voussoirs between the crown of the arch and the stone in question, and may be assumed to act at a distance x from A, measured along the joint A B. Then resolving the forces vertically and horizontally, and taking moments about the point D, we have the three following equations:

$$\begin{aligned} R \cos. \beta - P \cos. a - W &= 0 \\ Q \sin. \beta - P \sin. a &= 0 \\ f(x, Q, \text{etc}) &= 0 \end{aligned}$$

where $f(x, Q, \&c.)$ means an expression involving the quantities, x, Q, &c.

All the quantities involved in these three equations are known, except Q and x. Consequently there are three equations, and only two unknown quantities, and it follows that one of the equations, evidently the equation of moments, is a consequence of the other two. Since, then, the equilibrium of the voussoir is sufficiently provided for without using the equation of moments, which alone involves the point of application of P, it follows that for the equilibrium of the stone it is immaterial at what point of the stone the force P is supposed to act, and x may have any value that the depth of the stone will allow. Thus as regards the equilibrium of a single stone, the position of the resultant line of thrust is wholly indeterminate.

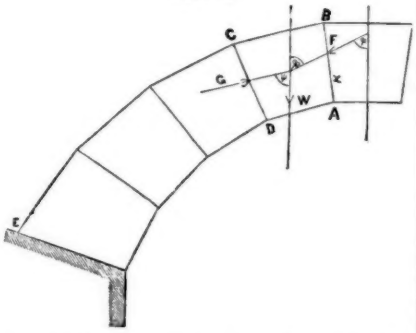
When, however, the arch, of which A B C D is a single voussoir, is considered collectively, it will be seen that the range of variation of the resultant line of thrust is reduced within more moderate limits. For the resultant line of thrust must not pass out of the arch either above or below, and this condition will reduce the range of x more or less according to the shape of the arch and the depth of the stones. Nevertheless there will in general remain a considerable range of variation, and the exact position of the resultant line of thrust is an indeterminate problem.

Consideration of an arch with friction between the voussoirs.

Suppose that an equilibrated arch as above considered has its equilibrium destroyed by the addition of a load upon the crown of the arch. Then the pressures at all the joints throughout the arch will be increased, and unless the friction between the stones were to come into play, each voussoir, as A B C D, would be thrust out of the arch upwards. At every joint, however, a force of friction will be called into action to oppose this tendency, which, together with the normal pressure between the adjacent stones, will be represented by a resultant force inclined to the joints

at an angle dependent on the amount of friction called into play. Let F and G represent these resultant forces in the case of the voussoir in the diagram, Fig. 2,

FIG. 2.



inclined to the vertical at unknown angles ϕ and ψ, and let the force, F, be supposed to act at a point distant x from A. Then, as before, the stone is in equilibrium under the action of the three forces, F, G, and W, and the conditions of equilibrium give rise to the following equations :

$$G \cos. \psi - F \cos. \phi - W = 0$$
$$G \sin. \psi - F \sin. \phi = 0$$
$$f(x, G, F, \phi, \psi, \text{etc}) = 0$$

where f (x, G, F, ϕ, ψ, etc.) means an expression involving the quantities x, G ϕ, F, ϕ, ψ, etc.: F is known in terms of the angle ϕ and the weights of the voussoirs, etc., between the crown of the arch and the stone in question.

Here, then we have three equations and four unknown quantities, viz., x, G, ϕ, and ψ; if we eliminate two of them, as G, and ψ, we obtain an equation of condition between x and ϕ, which will be satisfied by an infinite number of pairs of values of x and ϕ. Now ϕ depends upon the amount of friction acting along the joints, A B, and the equation of condition between x and ϕ shows that the amount of this friction may vary, provided that x undergoes a corresponding variation, as defined by the equation. Thus in this case also x has a range of variation, within the limits of which equilibrium may subsist, and the precise position of the reluctant line of thrust is, as before, an intermediate problem.

It is now possible to investigate the specific points of difference between the arch constructed of unconnected voussoirs and a continuous arch as constructed in wood or iron. This will be best demonstrated by considering the forces which the two forms of arch are able to bring into play to counteract the bending moment at any point of the arch. In the case of the voussoir arch above considered, let the portion A E, between the joint A B and the abutment, be supposed united in one rigid mass. Then the forces which act upon the mass A E are, (1) the thrust of the abutment; (2) the weight of the mass A E, acting through its centre of gravity; (3) the pressure at the joint A B. Let it be supposed that the mass A E is in equilibrium for a given disposition of load, when the force F acts at a distance [x] from A. Then the moments of the three forces about the point B balance one another, and the joint A B has no tendency to open either at A or at B. If now the disposition of load be altered, the forces will be altered and their moments about B will no longer balance one another, and there will be a resultant moment tending to make the joint open either at A or at B. Let it be supposed that the tendency of this resultant moment is to make the joint open at A. Then the point of application of the force F (which tends to open the joint at A) shifts nearer to B (as is permitted by the conditions of equilibrium stated in the last paragraph) so as to diminish the effect of its moment about B, and thus equilibrium is maintained. Finally, when the tendency to open at A is so great that it cannot be counteracted except the point of application of the force F retires past B, and outside the arch, then the joint opens at A, and the arch falls to pieces. From this is seen the great importance of depth for the stones of a voussoir arch. As regards the strain on the material of the arch this will be, of course, a simply compressive strain, distributed more or less according to the degree of elasticity which exists in the stone. It is certain that the edges of the voussoirs would crush or flake off long before the resultant line of thrust was driven to the outside surface of the arch; but the problem, as regards the strain on the materials, is, generally speaking, indeterminate, and the rules which have been established on the subject are entirely empirical.

In the case of the continuous arch it must be understood that there is acting

at every point a bending moment and a thrust force. The effect of these two as regards the equilibrium of the mass A E, will be represented by their resultant, which will be a single thrust force, acting at a point removed from the centre of the section, and precisely similar to the thrust force F of the voussoir arch ; but as regards the strain on the materials the effect is far more definite than in the case of the voussoir arch. For a continuous arch can bring into play forces of tension as well as forces of compression, and the bending moment is met by an opposite moment about the neutral axis of the arch, which is supplied by the resistance of the materials in the manner of an ordinary plate-girder. Thus in this case the arch relies upon the strength of the materials to resist the bending moment of the forces, and the total effect of the forces upon the material of the arch will be ascertained by combining with this moment the thrust of the arch, which will be known in terms of the weights and other forces which act upon the arch. This force of thrust will clearly increase the strain upon that side of the arch which is in compression in consequence of the bending moment, and will relieve that side which is in tension, so that in general the arch would fail by compression ; but in any case the stability of a continuous arch depends in a strictly definite manner on the strength of the materials, and thus it becomes possible, by using reliable materials of great strength, such as cast and wrought iron, the action of which under tension and compression is well known, to cross a wide span with much less depth of rib than would be required by a voussoir arch.

There yet remains a force which does not enter into the consideration of the bending moment either in the case of the voussoir arch or the continuous arch, viz.: the force along the surface of the section, which in the voussoir arch takes the form of friction between the joints, as already described, and in the continuous arch takes the form of a shearing force, which can be expressed in terms of the thrust force and the inclination of the curve drawn through the successive positions of the resultant force to the section in question. This shearing force will in general have but a very slight effect on the security of an arch.

The following investigation of the bending moment at any point of an iron arch is due to the Astronomer-Royal, and although the results are given only for the ordinary case of a circular arch, yet the method is equally applicable to the case of more complicated arches. As a preliminary to the investigation, the conditions of breaking and bending of an iron bar are prescribed in the two following propositions. Throughout the investigation the unit of length is supposed to be 1 ft., and the unit of weight the weight of a cubic foot of iron.

PROPOSITION I.

To investigate the criterion of breaking of a bar, by bending forces whose angular moment is M, at any particular point of the bar.

The bar will break when the bending force at the surface on the extended side is equal to the tension strength of iron. Call this (t), where (t) is to be expressed numerically by the number of feet in length of any bar who e weight will tear that bar asunder. Suppose the section of the bar to be a parallelogram (there is no difficulty in making a more general supposition when necessary), (b) its whole depth in the direction in which it will bend (the plane of the arch), and (a) its thickness. And suppose the neutral point to be in the centre of the bar's depth. Measure (x) from the centre towards the stretching side. The surface of that part of the section which corresponds to δx is $a.\ \delta x$; the extension is $\frac{2x}{b} \times$ extension at the tearing surface; the tension force for surface 1 is $\frac{2x}{b} \times$ tearing force $= \frac{2tx}{b}$; the tension force for surface $a.\ \delta x$ is $\frac{2at}{b} x.\delta x$; its moment round the neutral point is $\frac{2at}{b} x^2.\delta x$; the sum of all the moments from the centre to x is $\frac{2at}{3b} x^3$. Taking this from $x = -\frac{b}{2}$ to $x = +\frac{b}{2}$ (which includes the thrusting effect of the compressed side), the entire sum of moments is $\frac{4at}{3b} \cdot \frac{b^3}{1} = \frac{ab^2t}{6}$. At the moment of breaking this must $=$ M, or $M = \frac{ab^2t}{6}$.

PROPOSITION II.

To investigate the bending produced in a bar by bending forces whose moment is M; no consideration of breaking being entertained.

Suppose that a weight hung to a bar whose section is 1 will extend the bar by $e \times$ bar's length (e is a very small fraction). Let (r) be the radius of the curvature which the application of the moment M produces in the neutral line. At the distance (x) from the neutral line the fibres are lengthened in the proportion $r : r + x$, or by the $\frac{x\text{th}}{r}$ part of their length. And since an extension $e \times$ fibres' length corresponds to weight 1 on section 1, therefore an extension $\frac{x}{r} \times$ fibres' length corresponding to weight $\frac{x}{r.e}$ on section 1, and therefore to weight $\frac{x}{r.e}.a.\delta x$ on section $a.\delta x$. Therefore, the force actually exerted by the part $a.\delta x$ in its stretched state is $\frac{a}{r.e}.x.\delta x$, and its moment is $\frac{a}{r.e}.x^2.\delta x$; the sum of all the moments is $\frac{a}{3.a.e}x^3$; which from $x = -\frac{b}{2}$ to $x = +\frac{b}{2}$ becomes $\frac{2}{3}\frac{a}{r.e}.\frac{b^3}{8} = \frac{a.b^3}{12\,r.e}$. This sum of moments resisting the bending is equal to the moment producing bending = M. Therefore, $\frac{1}{r} = \frac{12.e}{a.b^3}.M$. This $\frac{1}{r}$ may be taken as the measure of curvature.

In the following investigation, if the dimensions of the bar were supposed to vary, we must use the factor $\frac{12.e}{a.b^3}$; but if we consider the dimensions of the arch to be everywhere the same, we may put E for $\frac{12.e}{ab^3}$, and then $\frac{1}{r} = E\,M$.

The course of the investigations will be:

1. The arch will be supposed to be an arc of a circle, of uniform breadth and depth throughout, loaded with a weight on its crown. (Probably there will be no difficulty, though some complexity, in varying both these conditions.) It is assumed that the depth of the arch is small compared with the span of the arch.

2. It will be supposed that the feet of the arch are prevented from spreading asunder. (There is no difficulty in supposing the feet free to spread; but this is not the case in practice.)

3. At any point of the arch, the moment M will be investigated, including terms which depend on the horizontal forces H, H, which prevent the feet of the arch from spreading asunder.

4. The impressed curvature at every part of the arch will therefore be found, including effects of H.

5. From these curvatures will be found the spread given to the feet of the arch, still involving H.

6. This spread will be made =0, whence H will be determined.

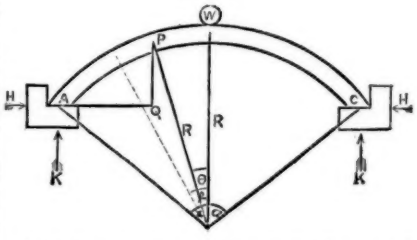
7. The value of H will be substituted in M (No. 3), and the explicit value of M at every point of the arch will be found.

8. The point of the arch will be found at which $\frac{6\,M}{a.b.^2l}$ (Prop. I.) is maximum; that point is the point most likely to break. If $\frac{6\,M}{a.b.^2l}$ is greater than 1, the arch will break there.

PROPOSITION III.

To investigate the moment M at any point of the arch.

FIG. 3.



Let A C be the arch, and P the point at which the bending moment is required to be known. The position of P is defined by its radial distance R from O, the centre of the circle, and the angle ϕ, which this radius makes with the vertical. P Q is a vertical from P, and A Q a horizontal line meeting P Q in Q. (α) is the angle of the half arch, and a. b. the sectional area of the rib.

The abutments are drawn in the rectangular state to show the resolved actions of the supporting forces; but they would be exactly the same if the abutments were inclined.

It is supposed in the figure that the bearing of the arch is at the point A, at

the moment of breaking. Strictly speaking, it will be most probably at B; but in what follows this merely makes the difference that we ought to have taken a rather longer arch, so that the radius to the assumed bearing point would have been directed towards B.

It is supposed that the arch is originally planted without any strain, or in exactly the same form which it would have taken if laid sideways on a horizontal plane.

For estimation of the moment about P, it will be sufficient to take one side of P (inasmuch as that on the opposite side is necessarily equal to it). Take it on the side towards A; then the whole moment to produce bend at P consists of the following parts:

The weight of the portion from P to A }
The force H }

in one direction, bending A downwards and inwards—and the force $K = R \propto a\, b + \frac{W}{2}$, in the opposite direction, bending A bending A upwards and outwards.

I. The portion from P to A.

The mass between ϕ and $\phi + \delta\phi$ is $a.\, b.\, R.\, \delta\phi$; its horizontal distance from P is $R\,(\sin\phi - \sin\theta)$; its moment round P is $a.\, b.\, R^2\,(\sin\phi - \sin\theta)\,\delta\phi$; the entire moment is $a.\, b.\, R^2\,(-\cos\phi - \sin\theta.\,\phi)$; taking this between the limits $\phi = \theta$, $\phi = \propto$, the entire moment around P of the portion from P to A becomes $a.\, b.\, R^2\,(\cos\theta + \theta\sin\theta - \cos\propto - \propto\sin\theta)$.

2. The force H.

Its moment round $P = H \times PQ =$

$$H.\, R\,(\cos\theta - \cos\propto).$$

3. The force $R \propto a\, b + \frac{W}{2}$

Its absolute moment is

$$\left(R \propto a\, b + \frac{W}{2}\right) \times AQ = \left(R \propto a\, b + \frac{W}{2}\right) + R\,(\sin\propto - \sin\theta)$$: but as this is in the opposite direction it must be taken

$$\left(R \propto a\, b + \frac{W}{2}\right) \times R\,(\sin\theta - \sin\propto).$$

Hence the entire value of M at P is

$$(a\, b\, R^2 + H.R)\,(\cos\theta - \cos\propto) + a\, b\, R^2\,(\theta - \propto)\sin\theta + (R^2\, a\, b\, \propto + \frac{R\,W}{2})\,(\sin\theta - \sin\propto) =$$

$$(a\, b\, R^2 + H\,R)\,(\cos\theta - \cos\propto) + a\, b\, R^2\,(\theta\sin\theta - \propto\sin\propto) + \frac{R.W}{2}\,(\sin\theta - \sin\propto).$$

PROPOSITION IV.

To find the impressed curvature at P.

By Proposition II., the reciprocal of the radius of the circle into which straight fibres are bent is $E \times M$. Or, the reciprocal of the radius of the circle into which straight fibres are bent, omitting the general factor E R, is

$$(a\, b\, R + H)\,(\cos\theta - \cos\propto) + a\, b\, R\,(\theta.\sin\theta - \propto\sin\propto + \frac{W}{2}\,(\sin\theta - \sin\propto).$$

If then we consider two points on the neutral line whose curve distances from the crown of the arch are R. θ, R. $(\theta + \theta\,\delta)$, the fibres at the second point are bent downwards with respect to their original direction in regard to those of the first by the angle

$$E.\, R^2.\, \delta\theta\left\{(a\, b\, R + H)\,(\cos\theta - \cos\propto) + a\, b\, R\,(\theta\sin\theta - \propto\sin\propto) + \frac{W}{2}\,(\sin\theta - \sin\propto)\right\}$$

PROPOSITION V.

To find the spread of the foot A.

(It will be convenient to estimate it positive in the inward direction.) Let the bend at the end of the last proposition be called $\Theta.\,\delta\theta$. Join A and P by a straight line. The bending will throw A through the space $AP \times \Theta.\,\delta\theta$, in the direction perpendicular to A P. The resolved part of this inwards is

$$AP. \times \Theta.\delta\theta \times \frac{PQ}{PA} = PQ \times \Theta\,\delta\theta =$$

$$R.\,(\cos\theta - \cos\propto).\,\Theta.\,\delta\theta = E.\,R.^3\,\delta\theta \times \left\{\begin{array}{c}(a\, b\, R + H)\,(\cos\theta - \cos\propto)^2 \\ a\, b\, R \times (\cos\theta - \cos\propto) \times (\theta.\sin\theta - \propto\sin\propto) + \\ \frac{W}{2} \times (\cos\theta - \cos\propto) \times (\sin\theta - \sin\propto)\end{array}\right\}$$

This must be integrated from $\theta = 0$ to $\theta = \propto$, to obtain the entire inwards spread of A, and, without giving the details of the integration, the entire expression for the spread of A inwards, omitting the factor $E\,R^3$, appears as

$$(a\, b\, R + H\left\{-\tfrac{3}{2}\sin\propto\cos\propto + \propto(\tfrac{1}{2}\sin^2\propto + \tfrac{1}{2}\cos^2\propto)\right\} + a\, b\, R \times \left\{-\tfrac{3}{4}\sin\propto\cos\propto + \propto(\tfrac{3}{4}\cos^2\propto - \tfrac{3}{4}\sin^2\propto) + \propto^2\sin\propto\cos\propto\right\} + \frac{W}{2} \times \left\{-\cos\propto + \cos^3\propto - \tfrac{3}{2}\sin^2\propto + \propto\sin\propto\cos\propto\right\}.$$

PROPOSITION VI.

To determine the value of H.

In this step is embodied the consideration of the lateral action on the abutment. If we omit H in every part of the investigation, we suppose that the ends of the arch rest on the top of flat piers. If we suppose, as above, that the spread is calculated relatively to what it would have been without any strain, and if we then (as we proceed to do) make the spread =0, this implies that the arch is planted in abutments, allowing only the same width as if the arch had been laid flatwise on a floor; now making the spread =0, we obtain

$$\begin{aligned} H \times \left\{ \tfrac{3}{2} \sin\alpha.\cos\alpha - \alpha(\tfrac{1}{2}\sin^2\alpha + \tfrac{3}{2}\cos^2\alpha \right\} \\ = abR \times \left\{ -\tfrac{3}{4}\sin\alpha.\cos\alpha + \alpha(\tfrac{3}{4}\cos^2\alpha - \tfrac{1}{4}\sin.^2\alpha) \right. \\ \left. + \alpha.^2 \sin.\alpha\cos\alpha \right\} \\ \frac{W}{2} \times \left\{ -\cos\alpha + \cos^2\alpha - \tfrac{1}{2}\sin^2\alpha + \alpha\sin\alpha\cos\alpha \right\} \end{aligned}$$

which gives H in two troublesome fractions. There is no difficulty in expressing it in any numerical instance.

It is worthy of remark here that, though it has been absolutely necessary to use the law and modulus of elasticity or extensibility in the investigation, yet they totally disappear from the result (which does not contain E).

(TO BE CONTINUED.)

THE LOSS OF THE "CAPTAIN."

From "The Engineer."

Never was journalist called upon to perform a sadder duty than that which we discharge by recording the foundering of Her Majesty's ship Captain, and the death of some 500 gallant men. The event is almost without a parallel, as regards the last hundred years, save that supplied by the sinking of the Royal George at Spithead. With the principal facts our readers are by this time thoroughly familiar. They have been very fully, and, for the most part, accurately, narrated in the columns of the daily press. It is impossible to put them more shortly or simply than they are stated in the following passage, which we extract from the "Times:"—

"Full details have now been received of this great misfortune. It occurred about 12.15 A.M. on the 7th inst., off Finisterre, the ship at the time being under double-reefed fore and main topsails, on the port tack, close hauled, with the wind about N.W. and very squally, with rain and heavy sea. About midnight the ship was felt making a very heavy roll to starboard, and before she had time to recover, a heavy sea struck her and threw her on her beam ends. She then turned bottom upwards, and eventually sank, going down stern first. From the time she fell on her beam ends to the time of sinking was about ten minutes. Captain Burgoyne and a few of the crew swam to the steam pinnace, which was floating bottom up; shortly afterwards the second launch passed close to the pinnace, and Mr. May, the gunner, and two men succeeded in getting on board, but Captain Burgoyne failed in the attempt. After various unsuccessful efforts to save him and others, they were so nearly swamped that they found themselves forced to bear up, or the launch must have gone from under them. At this time there were nineteen persons in the launch, but one man was washed out of the boat by her shipping a heavy sea, which nearly filled her. There was no sail in the boat, and only nine oars. Mr. May knew that land was dead to leeward of the ship, and at daybreak they sighted Cape Finisterre. At last the weather moderated, and they were able to land at Finisterre about noon on the 7th."

We have nothing to correct in the foregoing statement, nothing to add, except that steam was up at the time, but it does not appear that the engines were at work. Among those lost were Captain Coles and a son of the First Lord of the Admiralty. The death of the first gentleman is especially to be regretted by the advocates of the turret system; while that of the latter will, probably, do even more injury at present to a good cause. With Captain Burgoyne we have lost one of the most gallant and able young officers in the British navy; the only son of a man who has taken one of the highest possible places in

our profession. There is not an engineer who will not condole with Sir John Burgoyne on his bereavement. There are times, too, when technical knowledge is a direct source of regret to its possessor, and we confess that we wish we knew nothing about the internal arrangements of the "Captain" or any other steamship. Writers for the daily press have not had their souls harrowed by the picture which we cannot, do what we will, resist calling up of a scene presented by the stoke-hole of the ill-fated ship a few minutes before she sank. Her boilers were fired athwart ship, and the moment the vessel fell over on her beam ends the stoke-hole became a literal hell. The contents of the furnaces of the port boilers, now right over the unfortunate stokers, lying or standing on the starboard boiler fronts, must have forced the doors open by their weight, and poured in a fiery shower upon the men. The immediate destruction of the draught must have caused an irruption of flame and smoke which filled the stoke-hole; death by drowning came as a happy relief to wretches literary burning alive. No wonder that some of the survivors state that they heard the shrieks of the stokers above all the din of the storm. Such a death as the stokers of the "Captain" died falls happily to the lot of few shipwrecked men. It is none the less to be mourned over.

And now a question of prominent importance presents itself for consideration —Why did the "Captain" founder? Only a couple of weeks since we placed on record the fact that she has proved herself one of the fastest and stiffest ships under canvas in the Royal Navy. Yet a disaster has befallen her, the like of which never befell any modern ship of war. The fact will be explained by different men in different ways, but the prominent and all-pervading idea is, no doubt, that the ship had too little freeboard for stability; and a hasty condemnation will be passed on all turret ships as a consequence. We think it may be shown, however, that no deduction can be more illogical. Small freeboard is in itself no cause of instability. For example, it is possible to construct a raft of great width, capable of carrying a load quite as considerable as that on the deck of the "Captain," and with a freeboard of but a few inches, which it is impossible to overset. Stability—that is to say, the power of resisting a force tending to overturn a floating mass—depends, not only on freeboard, but on breadth of beam. We may reduce beam and increase freeboard, or reduce freeboard and increase beam with precisely the same result as far as stability, in the sense we have used the word, is concerned. The "Captain" had a freeboard of about 6 ft. 6 in. at the time of her loss. It was intended that she she should have had a freeboard about 21 in. greater, or, say, a little over 8 ft.; but by an error on the part of Messrs. Laird very similar to that committed by Mr. Reed in designing the "Bellerophon," the ship swam 21 in. deeper than she ought to have done. The chances are that this error led indirectly to the loss of the ship. We shall not now go into any elaborate disquisition of the question of stability and the principles which determine its amount in any given vessel. They have already been laid down in our columns. We shall simply deal with facts. We have been at the trouble to calculate the moment of stability of the "Captain," and we find that it progressively increased until the vessel heeled to about 15 deg. From that point it rapidly diminished. If the ship had floated higher in the water it is true that the centre of gravity would have been carried up; but the increase of freeboard would have more than compensated for the fact, and although we confess that we have only calculated the stability of the ship as she was, not as she was intended to be, we believe that she would have been much less likely to overset if she had been 8 ft. 3 in. out of the water instead of 6 ft. 6 in. The reports from the fleet state that for time before her loss the "Captain" was sailing close hauled, lying over at an angle of about 15 deg., and doing very well. But it is certain that at this angle her stability had reached its maximum, she had nothing whatever to spare. Then came a squall which "made the sea all white with foam." The ship heeled over still more under its influence. The angle of maximum stability was passed and we know the result. It has been urged that the pressure of the wind on the hurricane deck aided in preventing the righting of the hull but this is a fallacy to a very great extent indeed. There was, in the first place, a poop and forecastle, which increased the average freeboard, and so far deducted from the

influence of the wind on the hurricane deck. We have calculated the effective area of the remainder, and find that it was about two-thirds of that of the ship's main-topsail, and bearing in mind how close this area was to the water, and how small its leverage must have been, we cannot resist the conclusion that the hurricane deck had little or nothing to do with the catastrophe. There can be little doubt but that a careful inquiry into all the circumstances connected with the loss of the "Captain" will be carried out by the Admiralty at the first suitable moment; and until that inquiry is completed we do not care to express very decided opinions as to the immediate cause of the ship's loss, but we wish nevertheless to direct attention to one or two points. It must have been known at the Admiralty what was the ship's maximum angle of stability. Was Capt. Burgoyne in possession of the facts? Had he a diagram similar, we will say, to that contained in the paper on the Stability of Monitors, read on the 4th of April, 1868, by Mr. Reed, before the Institution of Naval Architects? If Capt. Burgoyne possessed such a diagram, he must have known that the moment the ship he commanded heeled 15 deg., she had reached her maximum limit of stability, and should have shortened sail. Our belief is, that neither Capt. Burgoyne, Capt. Coles, nor Messrs. Laird, really knew what was the maximum angle of stability of the ship. But the Admiralty either did know, or ought to have known, and, knowing, they should have imparted their information to the commanding officer of the ship. It may be urged that the Admiralty, as a rule—a very bad one, we may add—never do impart such information to commanding officers; but it must be borne in mind that the "Captain" was an exceptional ship, and that the Chief Constructor of the Navy had expressed very strong opinions about masting low freeboard vessels. In such a gale as was then blowing, it was not safe to carry more sail than would bear the ship down to about 8 deg., leaving 7 deg., or thereabouts, and about 2 ft. 6 in. of freeboard on the lee side of the ship, as a margin of safety. If, however, the Admiralty failed to supply all the requisite information to Capt. Burgoyne, they have been guilty of an error of judgment which has, directly or indirectly, led to the loss of the ship.

We have been already told that with the "Captain," masted monitors or low freeboard turret-ships disappear for ever. With this opinion we do not agree. We believe that, as we have already stated in a former article, the Government of this country would be very unwise if they built a second "Captain;" but we hold at the same time that the "Captain" upset, not because she was masted, but possibly because she was overmasted, possibly because she was injudiciously handled by an officer who did not and could not know all the merits and demerits of a strictly experimental ship. The "Captain" carried more sail for her size than any other iron-clad in the service, if the drawings of her rig which we possess are correct; and the putting of this enormous sail power into the ship was no doubt a fatal error on the part of Capt. Coles. But it does not follow because the "Captain" has gone to the bottom that it is impossible to mast a ship with a beam of 53 ft. —that of the "Captain"—and a freeboard of 8 ft. or 9 ft, in such a way that she will sail well enough to economize coal on all ordinary duty, and yet carry her sails with perfect safety in good hands knowing perfectly of what the ship is and is not capable.

It would but uselessly prolong this article to repeat here what we have repeatedly said as to the propriety of building ships which shall be monitors in action—ships with large freeboard at other times. It is possible, we believe, to design a ship with false bulwarks, which might be removed and thrown overboard, if necessary, in two hours, and yet very largely increase her freeboard at all other times. It is also possible to build a ship which, swimming 10 ft. or 11 ft. out of the water in ordinary service, could yet be sunk within 2 ft. of the water's edge, if need were, by taking in water ballast when going into action. On these points we shall not dwell now. It only remains to state that, in our opinion, the "Captain" was lost, not because she was masted, but because she was *over* masted; and secondly, because her commander did not know of what she was and was not capable.

The merits and demerits of turret ships remain to all intents and purposes practically unaffected, because there is not a competent naval man in the service

who did not know that the "Captain" was a very imperfect representative—good as she was—of the best possible iron-clad ship of war.

ON THE NATURAL LAWS OF MUSCULAR EXERTION.

By SAMUEL HAUGHTON.

From "Nature."

The experiments published by Mr. W. Stanley Jevons, in "Nature," on the 30th of June, last,* illustrate well two laws of muscular exertion which were established by experiments made by myself in 1862 and 1863. These laws may be thus stated:—

Law 1. The work given out by a single group of muscles, in a single contraction, is constant.

Law 2. When the same group of muscles is kept in constant action, the total work done by them until fatigue sets in, multiplied by the rate at which they are compelled to work, is constant.

Mr. Jevons' first series of experiments, in which different weights were thrown by the arm to various distances on level ground, illustrates the first law. In throwing weights in this manner, the arm, after a little practice, instinctively pitches the weight at the angle corresponding to the maximum range, and as the maximum range is proportional to the square of the velocity of projection, it may be used to replace that velocity squared, in estimating the work done by the arm.

The total work done is the same as if the weight used and the weight of the arm were concentrated at the centre of oscillation of the loaded arm, regarded as a compound pendulum.

Let us assume

w = weight held in hand;
x = weight of arm;
v = velocity of centre of oscillation.

By Law 1, the work done is constant and is represented by

$$(w + x)\, v^2 = \text{const.} \qquad (1)$$

Let

V = velocity of hand;
l = radius of oscillation;
a = length of arm.

then

$$v = \mathrm{V}\,\frac{l}{a} \qquad (2)$$

It is easy to show (assuming the arm to be a uniform cylinder) that

$$\frac{l}{a} = \frac{2}{3}\cdot\frac{(3w + x)}{(2w + x)} \qquad (3)$$

By means of (2) and (3), equation (1) becomes

$$\frac{(w + x)\,(3w + x)^2}{(2w + x)^2} \times \mathrm{R} = \mathrm{A}; \qquad (4)$$

where R denotes the range (proportional to V^2) and A denotes a constant, if Law 1 be true.

Mr. Jevons' experiments give the following corresponding values of w and R.

w.	R.
56 lbs.	1.84 ft.
28 "	3.70 "
14 "	6.86 "
7 "	10.56 "
4 "	14.61 "
2 "	18.65 "
1 "	23.05 "
½ "	27.15 "

We are required to assign certain values to x and A which will make equation (4) best coincide with the eight simultaneous values of w and R found by observation.

I find by trial that these values are

x = 8.1 lbs.
A = 262.2.

If we solve equation (4) for R, we find

$$\mathrm{R} = \frac{\mathrm{A}\,(2w + x)^2}{(w + x)\,(3w + x)^2} \qquad (5)$$

Substituting for A and x in this equation their values above given, we can obtain by calculation the distances to which the weights should be thrown, according to Law 1.

We thus obtain the following comparison between theory and observation.

w.	R (observed).	R (calculated).	Difference.
56 lbs.	1.84 ft.	1.90 ft.	− 0.06 ft.
28 "	3.70 "	3 51 "	+ 0.19 "
14 "	6.86 "	6.06 "	+0.80 "
7 "	10.56 "	10.02 "	+0.54 "
4 "	14.61 "	13.90 "	+0.71 "
2 "	18.65 "	19.11 "	−0.46 "
1 "	23.05 "	23.85 "	−0.80 "
½ "	27.15 "	27.39 "	−0.24 "

The agreement here shown between observation and calculation founded on Law

* See September number of this magazine.

1, is quite as complete as the agreement between observation and the empirical formula used by Mr. Jevons, which may be written, in the notation of the present paper, as follows:

$$(2\,w + 7.8)\,\mathrm{R} = 231.3. \qquad (6)$$

Mr. Jevons' third series of experiments consisted in holding various weights on the hand extended horizontally, and noting the time during which the weights could be so held.

The following are the weights and times observed :—

w.	t.
18 lbs.	14.8 secs.
14 "	32.5 "
10 "	60.3 "
7 "	87.4 "
4 "	147.9 "
2 "	218.9 "
1 "	321.2 "

Omitting the first of these experiments, I find that Law 2 satisfactorily accounts for the remaining six and gives a constant which is nearly identical with that obtained from my own experiments made in 1863.

When the arm is extended horizontally, if allowed to fall though an indefinitely small arc, the centre of oscillation falls like a free body under the influence of gravity, and the muscles then lift back the arm through the same arc, and this goes on continuously until the muscles are tired out.

Let us use the following notation:—

w and x are, as before, the weight held in the hand and the weight of the arm.

l = radius of oscillation ;
a = distance of centre of gravity of loaded arm from centre of shoulder joint;
δs = small space through which the centre of oscillation falls ;
n * = number of such falls during
t = whole time required to fatigue the muscles.

The total work done by the muscles in the time t, is evidently

$$(w + x)\,\frac{a}{l}\,n\,\delta s;$$

but $n\ \delta s$ varies as t, and therefore the total work done varies as

$$(w + x)\,\frac{a}{l}\,t.$$

The *rate* of work is evidently proportional to

$$(w + x)\,\frac{a}{l}$$

and since, by Law 2, the total work done before fatigue multiplied by the rate of work is constant, we obtain

$$(w + x)\,\frac{^2a^2}{l^2}\,t = \text{Const.} \qquad (7)$$

And since

$$\frac{a}{l} = \tfrac{2}{3}\cdot\frac{(2\,w + x)^2}{(w + x)\,(3\,w + x)}, \qquad (8)$$

we find by substitution,

$$\frac{(2\,w + x)^4}{(3\,w + x)^2}\,t = a. \qquad (9)$$

This equation (9) is the statement of Law 2, as applied to Mr. Jevons' experiments; and we are required to find values for x and a, which will make equation (9) best correspond with the given observations.

I find, by trial, that the following values will answer best :—

$$x = 7.4 \text{ lbs.}$$
$$a = 22{,}050.$$

If we solve question (9) for t, we find

$$t = \mathrm{A}\,\frac{(3\,w + x)^2}{(2\,w + x)^4}. \qquad (10)$$

From this equation, substituting the values of x and A, we obtain the following comparison of observation and theory:

w	t (observed).	t)calculated)	Difference.
14 lbs.	32.5 secs.	34.2 secs.	− 1.7 secs.
10 "	60.3 "	54.7 "	+ 5.6 "
7 "	87.4 "	84.8 "	+ 2.6 "
4 "	147.9 "	147.6 "	+ 0 3 "
2 "	218.9 "	234.4 "	−15 5 "
1 "	321.2 "	305.5 "	+15.7 "

This comparison is very satisfactory, the difference being much less than possible errors of observations. Mr. Jevons' experiments further show that the *useful effect* has a maximum corresponding to a certain weight. This weight, which gives the maximum of useful effect, may be readily calculated from Law 2.

By equation (10), the useful effect is

$$w\,t = \mathrm{A}\cdot\frac{w\,(3\,w + x)^2}{(2\,w \times x)^4}. \qquad (11)$$

This will be a maximum, when

$$(2\,w + x)\,(9\,w + x) = 8\,w\,(3\,w + x);$$

or when

$$6\,w^2 - 3\,x\,w - x^2 = 0.$$

or when

$$w = \frac{3 \pm \sqrt{33}}{12}\,x; \qquad (12)$$

* I have ascertained the number n from the acoustical observations made on the muscular *susurrus*.

or,

$$w = 0.73\,x.$$

Substituting for x its value 7.4 lbs., we find for the weight that gives the maximum useful effect,

$$w = 5.40 \text{ lbs.}$$

The useful effect observed by Mr. Jevons was as follows:

w.	Useful effect.
18 lbs.	266
14 "	455
10 "	603
7 "	612
4 "	592
2 "	438
1 "	321

The actual maximum corresponds to 5.4 lbs. lying between 7 lbs. and 4 lbs.

I may observe, in conclusion, that the difference of weights x of the arm, found in the two sets of experiments, is quite natural.

In the experiments in which the arm was held out horizontally, its weight 7.4 lbs., is the weight of the arm below the centre of the shoulder joint.

In the experiments in which the weights are thrown by the arm, a portion of the shoulder blade is in motion, in addition to the simple arm, and the total weight becomes 8.1 lbs.

MARINE ENGINES.

From "The Engineer."

The marine engine is undergoing just now a process precisely akin to that known in certain circles as a "revival." It underwent a similar process about ten years ago. It is the usual fate of revivals of all kinds that no lasting or permanent good comes of them. No good worth naming was done at the moment to steam navigation by the revival ten years ago. It remains to be seen whether the results of the revival of to-day will be more satisfactory. There is reason to hope that they will, because the enterprising practice of the engineers of to-day is based in a great measure on the experience afforded by the enterprising practice of engineers ten years ago, from which a great deal is to be learned. We enjoy advantages, therefore, which are peculiar to 1870, and had no existence in 1860. But the fact still remains, that experience alone will not teach any engineer how to effect improvements in marine engines. It will enable him to apply theory based upon fundamental natural laws to the best possible advantage, but it cannot compensate for a want of knowledge of these laws; nor can it enable results to be obtained in direct opposition to them. So far, therefore, as improvements in marine engines now being introduced are based on sound theory, and applied with strict attention to the lessons of experience, are they likely to be successful but no further. It follows that the questions of paramount importance to the marine engineer are questions of the applicability of the teachings of theory in practice. The art of reconciling the two in the best way represents one of the very highest developments of engineering science. Now, it is certain that little, if anything, was done to improve the marine engine ten years ago which was not based on the soundest theoretical deductions. It is demonstrably right to expand steam as far as possible. It is scientifically correct to supply a boiler with distilled water instead of salt. No engineer—using the word in its highest sense—would object to the axiom that steam should be thoroughly dried by the evaporation of suspended particles of water before it finds its way to the cylinder. Nevertheless, when expansion, surface condensers, and superheaters came to be applied to the marine engine some ten or twelve years ago, it was found that they were one and all failures. There is no necessity for mincing matters. They all failed, and they all cost those who tried them heavy sums for their temerity. But they did not fail because they were intrinsically defective. They failed because they were used without experience. We will not say that expansion, and superheating, and surface condensation are now being re-introduced after a more or less prolonged abandonment, because they have always been in modified use since they were first introduced. But we can say with perfect truth that they are now being used by some engineers in a way which, although contemplated by their inventors or proposers, was not found to succeed

some years ago. Thus we have not only an increasing tendency to use higher pressures than were formerly found to answer, but we have that tendency developed into actual operation. The same thing may be said of high measures of expansion, quick piston speeds, and, perhaps, of superheating. If these things are used in certain ways we know that they will fail now, as they have done already, to constitute improvements in marine engineering. It remains to be seen whether a happier result can be obtained by using them in a somewhat different way, in the first place; and in the second place, whether this use in a different way will or will not impair their efficiency. The questions thus opened up deserve the most serious attention of all mechanical engineers, whether engaged in marine engine building or not, because the steam engine is common to all mechanical engineers and much that is true of the land engine will apply to the marine engine, and *vice versa*; so that the maker or designer of land engines may not only learn a great deal from the marine engineer, but impart a great deal of information in return. The best way of arriving at sound conclusions on any subject is to learn all that can be said about it by good authorities. It is to be regretted that shipowners and engineers have hitherto proved far more reticent on all that concerns their work, than the general public will easily believe. There must, no doubt, be a great mass of information floating about as to the construction and working of the best marine engines and boilers which has never yet seen the light, in the shape of paper, discussion, books, or even pamphlets. Perhaps, one of these days a lot of it will be all collected and published, and the scientific world will then be in possession of what is sadly wanted, a thoroughly good work on the marine engine. Meanwhile we hail with no little satisfaction the publication, however limited, of any practical paper on steamship economy dealing with questions concerning it as things are, not as things were; and we find just such a paper in the twenty-ninth volume of the "Transanctions of the Institution of Civil Engineers," in the shape of a paper "on Ocean Steam Navigation," read by Mr. John Grantham, C. E., last December, and the discussion which followed it. Paper and discussion are alike full of valuable information. We are very sorry that they are not generally accessible. An attempt to abstract Mr. Grantham's paper, or the discussion which followed it, would do scant justice to both; but there are certain lessons conveyed which are highly instructive on several points, and admit of reproduction here.

One of the most important facts to be borne in mind in dealing with the subject of steamship economy is, that the ship which performs a given voyage with the smallest expenditure of fuel and the largest paying load, is, to all intents and purposes, the best ship that can be got. It is a mistake, however, to jump to the conclusion that the ship whose engines use the least coal must of necessity make the cheapest voyages. More, very much more, depends on the ship and the method of propulsion adopted than upon the engines. Thus, by merely cutting a ship in two, and lengthening her some 30 ft. or 40 ft., her paying cargo capacity has been doubled without in any way affecting the cost of propulsion or prolonging the duration of her voyage. The engineer when speaking to the shipowner, seldom hears much about consumption of coal per indicated horse-power, but he hears a great deal indeed about the consumption per voyage. Economy of fuel per horse-power is one means to the desirable end; but it is not everything, and we lay considerable stress on this fact, because there is no doubt that eminently economical engines, from being improperly put to work in badly designed boats, have completely failed to give satisfaction; the cost of such engines per voyage being considerably in excess of the cost of much worse engines placed in better boats and working under more favorable circumstances. The engines have been deemed the culprits, and really valuable improvements have been hastily condemned as failures. The existence of this truth was evidently fully recognized by both Mr. Grantham and his hearers, but there was not so much said on the subject as was desirable. All the speakers were agreed, however, that great length, in proportion to beam, was absolutely essential to economy. The truth of the proposition is demonstrated by the practice of the best builders of the day.

Although steam-engine economy does not alone secure steamship economy, it conduces powerfully to that desired end;

and it was to be expected that, considering many of the circumstances under which the paper was read, not a few instances of extraordinary economy of fuel would have been cited. The high character of the Institution, however, no doubt operated beneficially, and not a single speaker ventured even to hint at the wonderful tales sometimes told before less eminent societies, and less able judges of their truth or falsehood. On the contrary, the meeting evinced a general tendency to disbelieve in any statements of excessive economy. The advocates of the compound engine one and all spoke of the system, we were pleased to find, in much the same qualified terms of praise as we have ourselves bestowed on the principle of combination when applied to marine purposes. We especially commend to attention the opinions expressed by one of the speakers, himself a member of one of the largest and most enterprising firms of shipowners in the kingdom. He stated that he had given a great deal of attention to the question of steam navigation, more especially to the indicated horse-power developed at sea, and had come to the conclusion that shipowners greatly overestimated the power actually evolved, and consequently underestimated the consumption of fuel. On this point we have long held similar opinions, as in no other way can the extraordinary results said to have been attained, under certain circumstances, be accounted for. The speaker stated that from the best returns he could get he had arrived at the conclusion that in most of the steamers which performed their voyages at high speeds the consumption was $2\frac{3}{4}$ lbs. of coal per indicated horse-power per hour, and it was not till the speed was reduced to $8\frac{1}{2}$ or 9 knots per hour that a consumption of $2\frac{1}{2}$ lbs. was reached. It is quite possible that such a statement will be disputed, and it is, therefore, well to place before our readers figures either given by Mr. Grantham or by his hearers, bearing on the question. The Rakaia, built by Messrs. Randolph, Elder, and Co., for the Colonial Steam Navigation Company, of New Zealand, is 265 ft. long, 34 ft. beam; draught, loaded, 21 ft. Her engines are compound, the two large cylinders being 87 in., and the two smaller cylinders 43 in. diameter, by 4 ft. 3 in. stroke, geared; 27 revolutions of engines per minute to 67 of screw. The consumption of fuel is taken by Mr. Grantham to be 2.13 lbs. of coal per horse per hour, but he does not give the indicated horse-power as more than an assumption. The Somersetshire, one of Messrs. Wigram's ships, burned, at a low speed, 2.36 lbs. per indicated horse-power with ordinary engines, 20 lbs. steam, surface condenser and superheater, indicated power 650-horses, displacement about 3,900 tons. Mr. Stephenson spoke of a steamship which, on her first voyage to China and back, burned only 2 lbs. per indicated horse-power. Mr. Ravenhill stated that the consumption of fuel by the engines of the Peninsular and Oriental Company averaged 2.4 lbs. to 2.5 lbs. per indicated horse-power per hour. These are nearly, if not quite, all the instances in which the consumption per horse-power was cited. And although there are dozens of figures giving the total consumption per day, the speakers either could not or would not give the indicated horse-power. Mr. Bramwell gave an admirable example of the way in which inaccurate statements concerning economy of fuel at sea are put in circulation. The example was supplied by Mr. Grantham himself. That gentleman stated in the course of his paper that the Peru, a vessel fitted with compound engines of 350-horse power nominal, worked in running light from Glasgow to Liverpool up to 1,400-horse power indicated, her speed being 14 knots; the consumption of fuel not stated. He then went on to say that the Peru took in cargo, and the result of a voyage into the Pacific and back was that she burned 24 tons 1 cwt. of coal per day, which, using 1,400 as a divisor, Mr. Grantham took to represent 2 lbs. per horse per hour. But instead of the revolutions of the engines being the same as on her first trip when light, they corresponded to a speed of but 9-8 knots, which should be obtained with 410-horse power if the draught remained unaltered. But even allowing for the cargo, it was quite certain that nothing like 1,400-horse power was regularly developed, and the consumption was, therefore, more properly 4 lbs. per horse than 2 lbs. When we find careful, impartial authorities like Mr. Grantham falling into such a fallacious mode of reasoning as this, what can we expect of men who, however honest, cannot well help deceiving themselves? Not a single instance has ever come under our knowledge in which

a complete and accurate set of diagrams has been taken over a series of years in any marine engine-room, without proving that not only is the power developed overrated almost from the first, but that it goes on decreasing to the end as the boilers become foul or worn out. A chance indicator diagram, taken, say, once in a watch, when the pressure of steam is highest, and the engines doing best, is, as a rule, taken to represent the power exerted on the average during a whole voyage, not the slightest allusion being made to the pulling up of the engines by a head wind or a heavy sea. It is to the last degree desirable that makers of eminently economical engines should take the trouble of producing for the benefit of the scientific world the most complete statements of the indicated horse-power of the engine on long voyages. When they refuse to do this it is safe to assume that the conclusions of the users are based on insufficient data.

We have said so much concerning current evidence of economy in marine engines that we have not left ourselves space to deal at present with many other interesting features of Mr. Grantham's paper. After all, we are disposed to doubt the existance of any matter of more importance connected with steam-engine economy than the basis on which statements of engine builders and shipowners concerning certain types of machinery rest. When it is borne in mind that a difference of 0.1 lb. of coal per horse per hour will, in the case of steamships plying between England and the United States, represent a saving of £2,000 a year to the owners for a weekly service each way, it will be seen how important it is that the public should be placed in possession of not only the most complete but the most reliable information. Whether it is or is not possible to ascertain with some degree of certainty exactly what the indicated horse-power exerted throughout a long voyage is, we are not prepared to say; but it is quite clear that until such evidence is placed before us all statements concerning abnormally small consumptions of fuel must be looked on by sensible men with extreme doubt.

MODERN FIRE-ARMS—THE MARTINI-HENRY RIFLE.

From "The Engineer."

A report has just been issued by the committee appointed to settle the question of the new rifle for our army, which contains an analysis of the results of the trials of the 200 experimental arms issued to various regiments at home and abroad, and also to H.M. SS. Excellent and Cambridge, and the School of Musketry at Hythe. When these rifles were issued they were accompanied by a series of questions, which, after a considerable interval, during which the arms were put through various tests, were returned answered to the committee. These answers, with remarks by the committee, form the material of the Blue Book now before us.

The first point which it was desired should be cleared up was whether the rifle, as a whole, was more than ordinarily liable to injury, and here the reply appears to be most decidedly no. One or two casualties have occurred, the chief of which was the fracture of a tumbler, and nearly all arose from the use of faulty metal. None of them were peculiar to the construction of the arm, and each might have arisen with any other.

Difficulty in loading has occasionally arisen from the following causes:—Firstly, cartridges becoming bent; secondly, cartridges defective in minor details of manufacture; and, thirdly, the sharp edges of the chamber causing the paper covering to ruck up. In the majority of cases the extractor has worked satisfactorily, and where it has failed to do so allowances must be made for the want of experience on the part of the men using the arms. The motion of extracting in the Martini-Henry is so different from that in the Snider, that it is only natural to expect a little awkardness at first.

Many of these experimental arms have been severely tried by exposure to weather, and have not been found wanting. In one case they were piled in the open air, without cleaning for eight days, and were still perfectly serviceable. With regard

to the coil spring, the general tendency of the reports goes to prove that many of the springs that were issued were too weak, and that most of the missfires were attributable to this cause. M. Martini employs a spring of 40 lbs., though he nevertheless thinks that one of 33 lbs. will be sufficiently strong; but the springs of the rifles sent out from Enfield appear to have been of 26 lbs. only. The committee have, therefore, decided that in future the springs shall be made of the strength approved by M. Martini. From a calculation of the average number of missfires when eighty-six rifles were fired with the weak springs, and when the same rifles were fired with the stronger springs, we find that, with the weak springs, 163,277 rounds of ball and blank were fired with 3,814 missfires, showing a percentage of 2.34; but with the strong springs 26,463 rounds of ball and blank, missfires had been fired with only nine or a percentage of .034.

No objection is urged against this sudden extraction of the empty cartridge case, since it can, if desired, be easily controlled by opening the breech gradually, which is found to be an advantage in extracting a loaded cartridge. The divided stock has been found satisfactory with two exceptions, in which the butts are reported loose. One of these exceptions is rifle No. 100 at Quebec, which is constantly turning up under the various heads as a shortcomer, so we can fairly suppose it as having been a carelessly made arm. The reports as to recoil are somewhat contradictory, but we do not infer that it is excessive, though probably greater than that of the Snider. The Royal Engineers consider that it is too heavy a rifle for their wants; but the remainder of the reporters are of opinion that it is not unwieldy, at all events for ordinary men, though it might be "for some of the puny recruits now passed into the service." The back sight might be improved both in position and construction. In its present position, though well placed for sight, it interferes with the hand at the trail. The committee recommend the adoption of a flat sliding bar with three platinum lines, one long in the centre, and two shorter equally dividing the space on either side. They also recommend the addition of a platinum wire at the centre of the V, at the end of the flap. The sword-bayonet, which, it will be remembered, is a saw for a portion of its length on one side, is generally approved both as a weapon and as an implement of service. It is suggested that a few more teeth be added, to which the committee see no objection. A few complaints have been made that the weight of the sword when fixed detracts considerably from the accuracy of fire; but when it is borne in mind that the sword will only be fixed when troops come to close quarters, and when, consequently, accuracy of fire ceases to be unnecessary, the objection disappears. The fittings, so to speak, of the rifles, such as the cleaning apparatus and muzzle stopper, have also been reported upon; and we find that, on the whole, it seems desirable to retain them with trifling alterations. The tendency of the cleaning rod to come unscrewed is complained of, and some different means of securing it is necessary. Possibly a spring catch would be found to fulfil all requirements, and it would certainly be pleasanter to use.

So much of the reports as concerns the ammunition is very satisfactory. The evidence, as a whole, points to the advantage of a shorter cartridge, which, we are happy to say, has been provisionally adopted. The escape of gas from the base of the cartridge has been often noticed in the early use of the Snider rifle, and was found to arise from the cutting of the base cups against the rim of the chamber in rifles where the breech-block was too short. In the present trials, out of 137,308 rounds, only seven ball cartridges have been cut at the base, a very satisfactory proof of the excellence of the ammunition.

Generally, then, the opinion formed after the use of the experimental arms appears to be eminently favorable. The men are said to be greatly pleased with the weapon, and consider it far superior to the Snider. The rapidity of loading is found to be more than double that of the Snider, and the accuracy of shooting is much greater, the allowance for wind being considerably less. There seems to be no tendency to foul after continuous firing, and the manipulation of the breech is easy, simple, and safe. The arm is, however, generally objected to as too long, and the committee think also that a rifle of the same length as that in use by the Rifle Brigade and 60th Rifles would be more serviceable. There are objections

to a short rifle—for instance, in firing in two ranks standing; but the objections do not outweigh or even balance the advantages. The whole of the arms upon which the reports alluded to are based were hand-made, and consequently were not perfect or uniform. Many of the casualties mentioned in reply to the first question put by the committee are most probably due to this cause, and many of the missfires are explainable in the same way, through the strikers being too short. Where any difficulty in loading was experienced it was traceable to the long cartridges. As has been already mentioned, a shorter "bottle-necked" cartridge, without paper covering, will probably be finally adopted, and then, of course, the breech mechanism will also be proportionately shorter; so that when these alterations are carried out we shall be in possession of a breech-loader which it will be extremely hard to beat.

After wading through this and other blue-books, and reports relating to the Martini-Henry rifle, the question naturally arises—When shall we see it in use? It is now more than a year since the Martini-Henry was finally reported to be superior to the Snider, and yet we do not really seem to be much nearer the end than we were then. The committee are now engaged on the short-mechanism pattern, and we see that a new bayonet of Lord Elcho's design is to have a trial. Must we wait another year before anything is absolutely decided, and yet another before rifles are made in quantity sufficient to arm our troops? The position of the country under the present circumstances demands that the army shall be placed in the best possible state of efficiency. What prospect have we of the attainment of this desirable end as far as rifles are concerned? The regular troops and part of the militia have Sniders; the remainder of the militia and the volunteers have a weapon admittedly worthless, and it is said that we have 300,000 more Sniders in store. For the last three years we have been experimenting with the view of finding a substitute for the Snider, and now we can only hope to get it when the war is over, or, perhaps, when it is too late. Meanwhile the War Department is motionless, and our 300,000 Sniders remain in the galleries of the Tower and elsewhere—a magnificent but useless show.

SOME CHARACTERISTICS OF MODERN FIRE-ARMS.

As events thicken on the area of passing strife, many theories in respect to military fire-arms are tested by inexorable practice. Speculations as to the relative superiority or inferiority of fire-arms are narrowing themselves into the category of proven facts. At the commencement of this war both artillery and small arms had entered upon new phases; but it was in respect to military small arms chiefly that the greatest difference of opinion existed or was assumed to exist.

Speaking for ourselves, we never were of opinion that any slight shade of difference in the purely mechanical superiority of the Chassepot over the needle-gun, or the latter over the Chassepot, would count for so much as zealous advocates and partisans on either side expected. We have been in the habit of thinking little of the fact that the effective range of the French small arm is greater than that of the Prussians, or that the wounds inflicted by the Chassepot are more ragged and deadly in character. At any period before the breaking out of this war we should have been perfectly willing to concede that the Zundnadelgewehr is—taken all in all—a more imperfect mechanical strument than the Chassepot, which latter, however, has many defective points. Conceding all this, there was no time at which we should have been averse to credit the Prussians by anticipation with much of the success as marksmen that they have since achieved; our reasons for this belief mainly hinging on the fact, too often forgotten, that in a mechanical point of view an arm and its ammunition are not all in all. The physique and temperament of the shooter are items in the mechanical account—the soldier being to all practical intents an integral part of the machine.

This view has been amply borne out in all the contests which have occurred between French and Prussians up to the time when these remarks were made. It has been proved that the French temperament, by its impetuosity, its mobility, its desire to be doing something, has proved itself very much at a disadvantage in all that concerns the successful management of a military breech-loading small arm. Even in the old days of muzzle-loading, the great difficulty in action was to supply cartridges with due rapidity, many

instances having occurred in which soldiers have had to elect between injudicious bayonet charge or absolute retreat, merely because their ammunition had given out. This being the fact, it always seemed to us that two of the very advantages claimed by the French for the Chassepot over the needle-gun, namely, its longer range and its greater rapidity of deliverin fire, might turn out absolute disadvantages in the field. So far as events have gone, and can be accurately taken count of, this has absolutely seemed to have been the case. At the battle of Forbach groups of French infantry were seen making their way in disorder to the rear, merely because their ammunition had been all fired away ; and subsequently at Worth, MacMahon compained that his infantry had not been able to keep themselves supplied with ammuni ion in the contest.

Coming next to the mitrailleuse, it does seem wholly inexplicable, and not more inexplicable than ridiculous, that the French should have affected so much mystery in respect to a weapon that, whether good, bad, or indifferent, presents such obvious indications of constructive points to be carried out into practice, and which could have been executed in many different ways. The French Emperor, as most of us know, once wrote a folio book on artillery and fire-arms generally. His Majesty has ever since manifested a certain amateur predilection for this branch of the service ; but if, as would appear from published accounts, he has had anything to do with placing the mitrailleuse in the rank of an artillery instead of an infantry weapon, then we think his inspirations have led him very much astray. In some respects an instrument on the principle of the mitrailleuse has important functions and capabilities—perhaps we should rather say it is a machine that makes important promises, but we should have imagined that some of the most obvious considerations of what modern field artillery is expected to do would have led mitrailleuse constructors to determine its place as an infantry weapon from the first. By infantry weapon we mean that, although necessitating a service of its own, the mitrailleuse, its genius and construction regarded, should emulate small arms rather than artillery, if it would hope to give a good account of itself. In the present day field artillery is not worthy of the name if it does not embrace, or has not the faculty of embracing shell practice. Obviously no mitrailleuse light enough to take part in field evolutions could be endowed with that faculty to any but a limited extent. Weight and cumbrousness would be against it if made large enough for shell practice, and even were increased weight no longer a consideration it would still be undesirable to project shell in such a salvo from such a machine. We English have, no doubt, placed the mitrailleuse in its true prospective rank. Recent experiments at Shoeburyness have proved that it can advance no pretensions to rank as an artillery weapon; that it is especially an infantry weapon ; and, further, that to be effective the mitrailleuse should be able to employ the ordinary small arm service cartridge, of whatever description that may be. Here we must observe that the ordinary compound cartridge of the British service—the Boxer cartridge—does not appear to answer well for mitrailleuse purposes.

Relative to the barrel construction of the mitrailleuse, we have heard even mechanicians wonder why the expedient of aggregating 37 hexagonal barrels in a circumscribing case of wrought iron is resorted to, when, as seems to them, the much more simple expedient of boring 37 barrels out of a block of steel is at hand. If a mechanician, clever as he may be, would only try his hand at making a mitrailleuse in such fashion, his eyes might, perhaps, be opened and his opinion might alter. Some years ago Sir Joseph Whitworth, relying on accurate machinery, thought he could make double-barrelled fowling-pieces by boring two holes out of an elongated steel block. He found himself mistaken, as anybody would find himself mistaken who should make a similar attempt.

In the present contest between French and Prussians, artillery on either side has played a conspicuous part, but hitherto no sufficient intelligence has come to hand of the practice of the artillery employed. Hereafter we shall doubtless know, though at present we do not know, the relative value as now exemplified of howitzers and long field-guns in shell practice, and some light will be thrown on the specialties of shell fuses, both French and Prussian. Looking at our own artillery, it is quite clear that the segment Armstrong shell

and its mechanical fuse are both—to speak plainly—a failure. The result of practice at Dartmoor last year went to prove, amongst other things, that the Armstrong segment shell was next to useless against earthwork, and as against troops in the open field so much inferior to howitzer shrapnel that ordnance and ordnance material of this sort would be mainly relied upon should we, by force of events, be seriously engaged on an European field of battle.

STATISTICS OF AMERICAN IRON MANUFACTURE.

We take from the columns of the "Protectionist" the following extract from the forthcoming report of the Secretary of the American Iron and Steel Association :

BLAST FURNACE STATISTICS.

The development of the pig-iron manufacture that was noticed at length in our report for the years 1866, 1867, and 1868, continued with increased vigor during the year 1869. The remarkable growth of this branch of business during the past few years has, by no means, been confined to the older iron regions, from which, until recently, the principal supply of iron for the whole country has been drawn. Localities that have long been known as admirably adapted to the manufacture of iron, but which it has been supposed would not be called upon to yield their stores of mineral wealth for years to come, have suddenly loomed up into importance. Several States that five years ago were compelled to purchase every pound of pig-iron for consumption, now produce many thousands of tons annually. For some years prior to 1860, Indiana produced a small quantity of charcoal pig-iron, about 1000 tons per annum. From that time until 1867, no pig-iron of any kind was made in the State. In 1867 a large bituminous coal furnace, with a capacity of 9000 tons per annum, and employing a capital of $150,000, was erected at Brazil, Clay county. In the following year two furnaces were built, with a capacity of 7500 tons each, with a capital of $200,000. The same year another furnace was built in Clay county, with a capacity of 3600 tons, and employing a capital of $100,000.

Last year a fifth furnace was blown in in the same locality, having a capacity of 3600 tons and a capital of $125,000. A sixth furnace, at Terre Haute, has just been completed, having a capacity of 7500 tons, and employing a capital of $150,000. These furnaces produced, in 1869, about 23,500 net tons of iron. Their united capacities are 35,000 tons per annum, and a capital of $725,000 is employed in their operation. Four additional furnaces would have been erected during the course of the present year but for fear of legislation adverse to the iron interest. In Illinois, prior to 1859, a few hundred tons of pig-iron was made annually. From that time to the beginning of last year there was not an active furnace in the State. Within the past eighteen months, however, the business has received a new impetus. Six large stone-coal furnaces have been erected ; four of these are in the vicinity of Chicago, and two at Grand Tower, in Jackson county, on the Mississippi river. We hear of a seventh in course of construction, but cannot now name the locality. Thus, in the short space of eighteen months, Illinois has acquired a capacity for producing from 50,000 to 60,000 tons of pig-iron. A bituminous coal furnace, having a capacity of 35 tons per day, has been erected at Milwaukee, Wisconsin. Five large stone-coal furnaces have been built in Missouri within the past year. That great and growing State has now a capacity of 300 tons of pig-iron per day, with means for greatly increasing the production should legislation be propitious.

To show the condition of the iron manufacture in Eastern Kentucky, we can do no better than quote from a letter recently received from a gentleman living near Ashland, in that State. He says : "During the last three years, two large stone-coal furnaces and two charcoal furnaces have been built near this place, all within sight of each other, on the bank of the Ohio river. Raccoon, Buffalo, Lovel, Greenup, and Kenton furnaces, that were all idle during the depression before the war, have started again within three years, and, if Congress will let our tariff alone, two additional stone-coal furnaces

will be built near this place during the present year. The Lexington and Big Sandy Railroad is now in a fair way to be finished, opening up a vast ore and coal region, in which many new furnaces could be erected. The Kentucky Improvement Company propose to build or extend their road 30 miles, to a large deposit of ore, opening up a great charcoal section, and transporting ore to the river for sale and to smelt in furnaces which they propose to build. It is easy to see how a depression in business would affect these enterprises. The furnaces would not be completed, the roads would not be built, and the region of country, 125 miles long and 75 wide, now a wilderness, would remain as it is. Let prosperity be guaranteed to us by an adequate tariff, and what a change we would see—furnaces every few miles, giving employment to a hardy, industrious people; this whole section changed from a hunter's wilderness to the most wealthy and valuable part of the State."

In several of the Southern States, where before the war a few hundred tons of iron only were made in forge fires, companies are being formed and capital raised for the purpose of converting their beds of coal and of pure and rich ores into the many products required by a growing diversity of interests. Many of the present most active champions of home labor came from that section of our country.

ANTHRACITE IRON STATISTICS.

In the States north and east of Pennsylvania, the production of anthracite iron in 1869 was 269,256 tons, as follows :

	Tons.
New Jersey	54,201
New York	210,855
Massachusetts	4,200

The production of anthracite iron in these States has arisen from 64,969 tons in 1864, to the quantity above given in 1869. The anthracite furnaces in the States above named were erected as follows : 1 in 1844, 2 in 1845, 3 in 1847, 2 in 1848, 3 in 1850, 3 in 1852, 3 in 1853, 4 in 1854, 1 in 1855, 2 in 1857, 2 in 1860, 3 in 1861, 1 in 1862, 3 in 1864, 2 in 1865, and 8 since 1865 ; 8 of the whole number have been abandoned and dismantled.

The following statement shows the progress of this branch of manufacture in the States above named :

Years.	Mass.	New York.	New Jersey.	Total.
1854	4,978	35,619	24,372	64,969
1855	7,181	49,728	31,754	88,663
1856	3,855	52,826	29,247	85,928
1857	3,900	46,486	22,785	73,171
1858	3,000	49,380	16,447	68,827
1859	1,000	68,281	28,394	97,686
1860	——	79,509	27,092	106,601
1861	——	66,793	24,000	90,793
1862	——	72,702	27,500	100,202
1863	——	109,992	38,000	147,992
1864	2,509	121,863	41,000	162,863
1865	3,000	80,420	16,195	99,615
1866	3,606	118,274	40,680	162,560
1867	3,500	151,586	36,919	192,005
1868	4,000	160,681	47,209	211,890
1869	4,200	210,855	54,201	269,256

The production of anthracite pig-iron in Pennsylvania in 1869, was 692,739 tons. Of this quantity, 300,916 tons was made in the Lehigh region ; 150,409 tons in the Schuylkill region ; 123,273 tons in the Upper Susquehanna ; and 118,141 tons in the Lower Susquehanna. This product exceeds, by 20,784 tons, or 3.09 per cent., that of 1868; 98,469 tons, or 14 per cent., that of 1867 ; 118,980 tons, or 20¾ per cent., that of 1866.

This branch of manufacture exhibits the greatest growth on the Lehigh, and the least on the Susquehanna. Within the past three years 14 furnaces have been erected in the first-named locality, including two or three nearly completed, increasing its capacity about 140,000 tons. The product of the older furnaces has been increased materially by new appliances, enlargements, etc. In the Schuylkill region, the average annual increase for the past six years has been 16⅔ per cent. The capacity of this region may be set down at fully 180,000 tons.

The following statement shows the whole product of anthracite pig-iron for the past eight years :

Years.	Tons.	Years.	Tons.
1862	370,304	1866	573,750
1863	433,072	1867	594,270
1864	519,690	1868	671,955
1865	377,433	1869	692,730

The production in Maryland for 1869 of anthracite pig-iron was 9,155 tons.

The total product of anthracite pig-iron in the United States in 1869, is thus shown to be as follows :

	Tons.
Massachusetts	4,200
New York	210,855
New Jersey	54,201
Pennsylvania	692,739
Maryland	9.255
Total	971,150

The yearly product of anthracite iron for the past 10 years has been as follows :

Years.	Production. Tons.		Incr. or Decr. Per cent.
1860.....	519,211		
1861.....	409,229	....	decr. 21.18
1862	470,315	....	incr 14.90
1863.....	577,638	....	incr. 22.82
1864.....	684,018	....	incr. 18 41
1865.....	479,558	....	decr. 29.89
1866	749,367	....	incr. 56.26
1867.....	798,638	....	incr. 6.57
1868.....	893,000	....	incr. 11 80
1869.....	971,150	....	incr. 8.75

RAW BITUMINOUS COAL AND COKE IRON.

The production in 1869 amounted to 553,341 tons, an increase of 213,341 tons, or 62.74 per cent. over that of 1868, and 235,694 tons, or 73.65 per cent. over that of 1867, and 284,345 tons, or 105.7 per cent. over 1866. In 1854 the production of this class of iron was 54,485 tons, since which the annual average increase has been 54½ per cent.

There was great progress made by this class of business in several localities during the past few years ; in illustration of this we will cite a few instances.

In 1864 there were eleven furnaces of this class in the Shenango Valley, Pennsylvania, the oldest of which was erected in 1844. The capacity of these furnaces was about 45,000 tons annually. During the five following years, to 1869 inclusive, there were erected in that locality ten additional stone-coal furnaces, having a capacity of from 85,000 to 95,000 tons, and employing a capital of $800,000. During the same time, three charcoal furnaces were built in the valley, with a capacity of 8,000 tons, costing about $50,000. The capacity of the old furnaces has been increased fully 25 per cent. by reversion and enlargement during the past five years. In the Hanging Rock region of Ohio, five bituminous coal furnaces have been built or rebuilt within three years, increasing the capacity of that region 40,000 tons per annum. These new furnaces employ a capital in works and ore and coal lands of over one million of dollars. A similar development in the charcoal manufacture has taken place in the same locality. In the Mahoning region, in Northeastern Ohio, twelve new bituminous coal furnaces have been built within three years ; four were blown in in 1867, five in 1868, and three in 1869. These new furnaces have an annual capacity of 95,000 tons, and cost $750,000. Two large bituminous furnaces have recently been erected in Michigan, one in the vicinity of Detroit, the other in the upper Peninsula—the latter, according to the latest advices, is about to be blown in. Of the growth of this branch of the pig-iron manufacture in Indiana, Illinois, and Missouri, we have frequently spoken.

CHARCOAL IRON.

The production of charcoal iron in 1869 amounted to 392,150 tons, as follows :

	Tons.
New England States.....	38,000
New York, New Jersey, Penn'a, and Md..	134,000
Western States.....	206,500
Southern States	13,650

This quantity exceeds by 22,150 tons, or about 6 per cent., the product of 1868; 47,809 tons, or 13.88 per cent. that of 1867, and 59,570 tons, or 17.91 per cent. that of 1866.

The annual production of charcoal pig-iron in the United States for many years past has been quite variable, as the following statement will show:

Years.	Production. Tons.		Incr. or Decr. Per cent.
1854.....	342,298	....	
1855.....	339,922	....	decr. 7.10
1856	370,470	....	incr. 9
1857.....	330,321	....	decr. 10½
1858	285,315	....	decr. 13½
1859.....	284,041	....	decr. 4 10
1860.....	278.331	....	decr. 2
1861	195,278	....	decr. 29
1862.....	186,660	....	decr. 4
1863.....	212,005	....	incr. 13
1864	241,753	...	incr. 14
1865.....	241.853	....	incr. 14
1866.....	332,580	....	incr. 26½
1867.....	344,341	....	incr. 3
1868.....	370,000	....	incr. 7
1869.....	292,150	....	incr. 5

It will thus be seen that, with the exception of a single year, there was a steady falling off in the production of charcoal iron from 1854 to 1862 inclusive, and as steady an increase from 1862 to the present time.

While but little progress has been made in this branch of manufacture in the New England and Middle States during the past three years, its growth in the West has been exceedingly gratifying.

Within that period a number of furnaces have been built in Ohio, largely increasing the capacity of that State for making this kind of iron. In Michigan 6 new charcoal furnaces have blown in, having a total capacity of between 30,000 and 40,000 tons. In Wisconsin, a new

charcoal furnace was put in blast in 1869, another has been blown in since the beginning of the present year, and a third is now in process of construction. Two new furnaces using charcoal for fuel have been built in Missouri and several in Kentucky. In the Southern States a number of old charcoal furnaces that went out of blast when the war ended, have recently been repaired and lighted. They are located as follows: One near Lincolnton, N. C., making about 1,500 tons per annum, a considerable part of which is converted into hollow ware and other light castings for local consumption. Two in Cass County, Georgia, which made, in 1869, 487 tons of charcoal iron, most of which was also made into hollow ware. Three in Alabama, which made respectively 500 tons, four, 908 tons, and one, 756 tons. The last-named State is making a great effort to develop her mineral resources. The late Legislature passed an act granting aid to several important railroad companies, upon the condition that in the construction and equipment of said roads preference must be given, terms being equally favorable, "in all contracts for cross ties, rails, chairs, spikes, joint fastenings, locomotives, cars of all kinds, and other materials and equipments, to the proprietors of such foundries, mills, manufactories and other works, as are engaged in the manufacture of iron, of ores, and of other raw materials found in the limits of the State of Alabama."

TOTAL PRODUCT OF PIG-IRON OF ALL KINDS IN THE UNITED STATES IN 1869.

	Tons
Tons	1,916,641

As follows:

Anthracite pig-iron,	971,160
Raw bituminous coal and coke pig-iron,	553,341
Charcoal pig-iron	392,150

The product in 1865 was 931,000 tons, it having more than doubled in four years. This enormous increase in the production is due in a great measure to the operation of a protective tariff, and the noble response of this industry to the requirements of the country overthrows some of the most plausible theories of free trade.

ROLLING MILL STATISTICS.

The production of the rail mills for 1869 was as follows:

	Tons of 2,000 lbs.
Massachusetts	32,238
New York	79,463
Pennsylvania	319,653
Maryland	27,328
Ohio	41,837
Kentucky	7,817
Michigan	6,885
Illinois	53,261
Wisconsin	8,680
Other States	16,424
Total	593,586

The progress of this branch of manufacture during the past ten years is shown by the following table:

1869	205,038 tons of 2,000 lbs.			
1861	189 818 "	" Decrease,	7.4 p. cent.	
1862	213.913 "	" Increase,	12.5	"
1863	175,703 "	" "	28.9	"
1864	335,369 "	" "	21.6	"
1865	356.292 "	" "	6.2	"
1866	430,778 "	" "	20.9	"
1867	462,108 "	" "	7.3	"
1868	506,714 "	" "	9.6	"
1869	593,586 "	" "	18.12	"

IMPORTATION OF RAILS.

During 1869, we imported from Great Britain 336,500 tons of rails, an increase of 36,340 tons as compared with the imports of 1868, 151,459 tons over 1867, and 216,622 tons over 1866. As we imported a few rails from other European countries, the total importation probably amounted to 345,000 tons, making, with the 593,586 tons manufactured here, a total consumption of 938,586 tons. Taking into consideration the growth of our railroad system, the requirements of the country for the coming five years will doubtless average over a million tons per annum. Of the product of rails for 1869, 9650 tons were Bessemer steel. The erection of one or two large rail mills is in contemplation, which will increase the capacity of our works beyond the total consumption of rails last year.

PRODUCT OF ROLLING MILLS OTHER THAN RAILS,

for 1869, was 642,420 tons, which may be divided as follows:

	Tons.
Merchant bar and rod	292,500
Sheet	36,320
Plate	68,000
Hoop	17,200
Nails and spikes	146,400
Axles and other	72,000

Of these manufactures we imported 120,795 tons; making a total consumption of rolled iron other than rails, in 1869, of 763,215 tons.

PRODUCT OF FORGES AND BLOOMARIES IN 1869,

was 69,500 tons, a slight decrease as compared with the average of the past five years.

Of steel of all kinds the product was 35,200 tons, of which nearly 12,000 tons was made by the Bessemer process.

From the reports of the British Board of Trade we find that the exports of iron of all kinds to the United States, from the various British ports (which represents nearly all the foreign iron entering into consumption here), during the year 1869, was as follows:

	Tons.
Pig-iron,	148,383
Bar, angle, bolt and rod,	62,807
Rails of all sorts,	336,500
Castings,	2,076
Hoop, sheet, and boiler-plate	37,233
Other wrought iron,	9,555
Total,	596,554
Steel,	18,601

By comparing these figures with those of the previous year, we find that of pig-iron the increase in 1869 was 54 per cent.; bar, angle, bolt and rod, 28 per cent.; railroad iron, 12 per cent.; hoops, sheet, and boiler plate, 80 per cent.; other wrought iron, 71 per cent.; casting, 45 per cent. Total increase iron, 26 per cent. Of steel there was a decrease of about 3 per cent.

The history of the iron ore trade of the Marquette or Lake Superior region for the year 1869, is exceedingly satisfactory. During the year, 709,387 tons of ore were mined, the value of which, when loaded in the cars at the mines, is estimated at $3,166,190. The existence of iron ore in this region was made known in the year 1830, but the first opening was not made until late in the year 1846. From that time to the end of the year 1855, only about 25,000 tons were mined. Since the latter year the trade has grown with wonderful rapidity, the total quantity mined during the fourteen years that have since elapsed, reaching the vast aggregate of 2,274,490 tons. From this ore, over 2,000,000 tons of pig-iron have been smelted, a quantity equalling the whole production of the country during the year just closed. From the excellent History of the Iron Mines and Furnaces of the Lake Superior District, by A. P. Swineford, Esq., recently published, the following statement, showing the yearly production of ore in that region since 1856, is compiled:

Year.	Tons of 2,000 lbs.	Year.	Tons of 2,000 lbs.
1856	7,840	1864	263,338
1857	23,520	1865	219,807
1858	34,759	1866	332,609
1859	73,560	1876	522,005
1860	130,937	1868	568,750
1861	50,882	1869	700,387
1862	129,608		
1863	207,488	Total	3,274,490

FOREIGN IRON TRADE.

A few words touching the foreign iron trade for 1869 may not be inappropriate here.

In Scotland the demand for pig-iron at the commencement of the year was rather inactive, the price being 55s. cash. Trade was dull during the spring, and prices, after reaching 55s. 7d. cash, in March, to 52s. 9d., and finally near the close of May, receded to 50s. 7d. In June the trade improved, and prices went up again to 57s. 1½d. cash, again receding in July to 50s. 6d. From that time to the end of the year business steadily improved, the price advancing steadily until the close of the year, when it reached 57s. 3d. cash for mixed numbers f. o. b. The average price for the year was 53s. 3d. per ton, about 5s. below the average annual price for the last twenty-five years. The production during the year amounted to 1,150,000 tons, against 1,068,000 tons in 1868. At the close of the year there were 158 blast furnaces in Scotland, 120 of which were in blast. The stock of pig-iron in Scotland increased during the year 52,000 tons, there being 620,000 tons in store at the beginning of the present year. The foreign shipments of pig amounted to 388,639 tons, an increase of 64,620 tons. Of this increase nearly 50,000 tons was to this country.

In the great Cleveland district, which produces about one-fourth of the whole product of pig-iron in Great Britain, the iron manufacture was steadily progressive, and notwithstanding a largely increased make, the year closed with a lighter stock on hand than at the close of either of the two preceding years. The production of pig-iron in this region in 1869, was 1,459,500 tons, against 1,233,400 tons in 1868, an increase of 226,100 tons. The stock on hand was reduced 37,300 tons during the year. The price of Cleveland pig No. 3 was 45s. on the first day of January, 1869, and fluctuated but little during the spring.

In the summer the price fell to 43s. 6d. In September a heavy demand set in, principally from rail-makers, and the price rose to 50s. 6d. cash f. o. b.

The principal vitality in the Welsh market during the year was in the manufacture of rails, for which more remunerative prices were obtained than for other kinds of iron. A brisk demand for rails for the East India, Russian and United States markets continued throughout the year.

The exportation of iron of all kinds from Great Britain for 1869 has not yet appeared. The quantity of pig-iron made is estimated by the best authorities at 5,250,000 tons.

The exportation of iron of all kinds from Great Britain last year was conducted upon an immense scale.

	Tons.
Exportation of pig and puddled iron, ...	771,612
Against 552,999 tons the previous year.	
Of bar, angle, bolt and rod.	357,604
Against 302,624 tons in 1868.	
Of railroad iron the increase was marvellous,	895,848
Against 583,488 in 1868; an increase of 312,360 tons, or 53 5 per cent.	

The whole of the increased activity noted was due to the heavy demands of Russia and the United States, the former taking 252,827 tons and the latter 300,446.

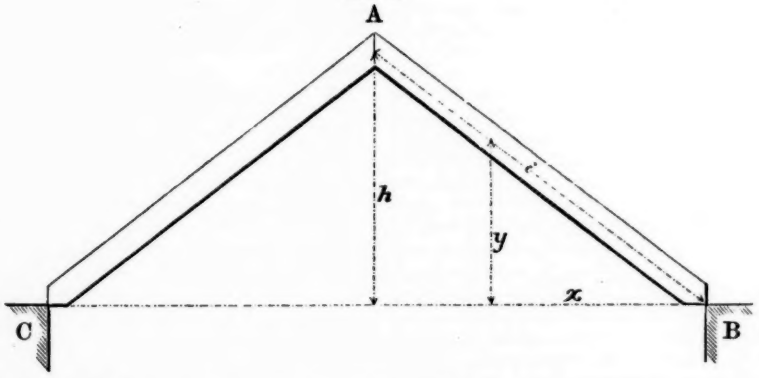
Castings were exported to the extent of 106,472 tons, compared with 85,504 tons in 1868; of hoops, sheets and boiler-plates 195,670 tons, against 150,231 tons the previous year; of miscellaneous wrought-iron 134,113 tons, as compared with 121,480 tons in 1868. The quantity of all kinds of iron exported was 2,577,493 tons, against 1,944,731 tons in 1868, an increase of 632,662 tons, or 32½ per cent.

STRAINS IN RAFTERS.

By S. H. SHREVE, C. E.

Rafters, and more especially trussed rafters, of great length are not in common use, and there may seem to be little need of the results of the investigations of the following paper in general practice. But the obscurity that exists in regard to the strains affecting rafters, and the consequent proof of the value of the methods which I have used in determining the strains in horizontal girders,* are sufficient reasons for the following investigations as an intermediate step between the consideration of horizontal and of arched trusses.

Fig. 1.



Mr. Stoney in his work on Strains, page 77, says of the strains affecting rafters, "an accurate investigation would be very complicated if not altogether impracticable."

This may be true in a certain sense only, as we cannot tell what lines strains take in a solid beam, whether inclined or horizontal, but it is not true in a flanged

*See pages 193 and 417 of the present volume of this magazine.

or trussed rafter any more than in a girder.

On page 76, Mr. Stoney also makes this singular assertion: "The longitudinal component of W compresses the rafter like a pillar, and accumulates gradually from the ridge, where it equals cipher, to the wall-plate, where it equals $\frac{h\,W}{2\,l}$." Our investigations lead to a very different result.

Let Figure 1 represent a pair of rafters, A B and A C.

Let w = the weight uniformly distributed over the pair.
s = the span of the roof.
l = the length of each rafter.
h = the height of the ridge above the wall.
x = the horizontal distance of any point in the rafter from the wall.
y = the vertical distance of the same point above the wall.
L = the longitudinal strain.

Each rafter is held in equilibrium by the horizontal thrust of the opposite rafter, the uniformly distributed weight of the roof, $\frac{w}{2}$ acting downward, the vertical reaction of the wall, which is $\frac{w}{2}$ and the horizontal reaction of the wall.

Taking moments around a point in the line of the top of the walls, distant x from one abutment, we have for the moment of the reaction of the wall, $\frac{w}{2} \times x$ in one direction; in the opposite direction we have the weight on $x = \frac{w}{s} \times x$ multiplied by the distance of its centre of gravity $\frac{x}{2}$, or $\frac{w\,x^2}{2\,s}$. Subtracting these, we have the moment of the longitudinal strain, which is L, multiplied by the distance at right angles to its direction from the point around which the moments are taken. This distance can be obtained from similar triangles by the proportion,

$$l : \frac{s}{2} :: y : \frac{s\,y}{2\,l}.$$

$\frac{s\,y}{2\,l}$ is the distance, and $L \times \frac{s\,y}{2\,l}$ the moment of the longitudinal strain, and consequently,

$$\frac{L\,s\,y}{2\,l} = \frac{w\,x}{2} - \frac{w\,x^2}{2\,s} \text{ and } L = \frac{w\,l\,x}{s\,y} - \frac{w\,l\,x^2}{s^2\,y} \quad (1)$$

Again from similar triangles

$$x : y :: \frac{s}{2} : h \text{ or } \frac{x}{y} = \frac{s}{2\,h},$$

Whence, $\frac{w\,l\,x}{s\,y} = \frac{w\,l}{2\,h}$, and equation (1) assuming this form

$$L = \frac{w\,l}{h}\left(1 - \frac{x}{s}\right). \quad (2)$$

The values of x in this and the subsequent equations are limited between $x=0$ and $x = \frac{s}{2}$.

Making $x = 0$, $L = \frac{w\,l}{2\,h}$, the longitudinal strain at the wall; making $x = \frac{s}{2}$, $L = \frac{w\,l}{4\,h}$, the longitudinal strain at the ridge.

In the above case, the moments were taken about a point where the horizontal reaction of the wall has no moment, merely to show that the longitudinal strain varies, and consequently that other strains, or strains having other directions, exist in a uniformly loaded rafter.

To ascertain these strains let A B in Fig. 2, represent a rafter which is a flanged beam, connected to the opposite rafter, and the wall by the upper flange only.

Let w, s, l, h, x, y and L have the same value as before, and let d = the depth of the rafter at right angles to its length.

h, x and y are measured to points in the upper flange.

All the strains between the two rafters pass through A and all the strains to the wall pass through B. From similar triangles, $\frac{s}{2} : l :: d : \frac{2\,d\,l}{s}$, the vertical depth of the rafter.

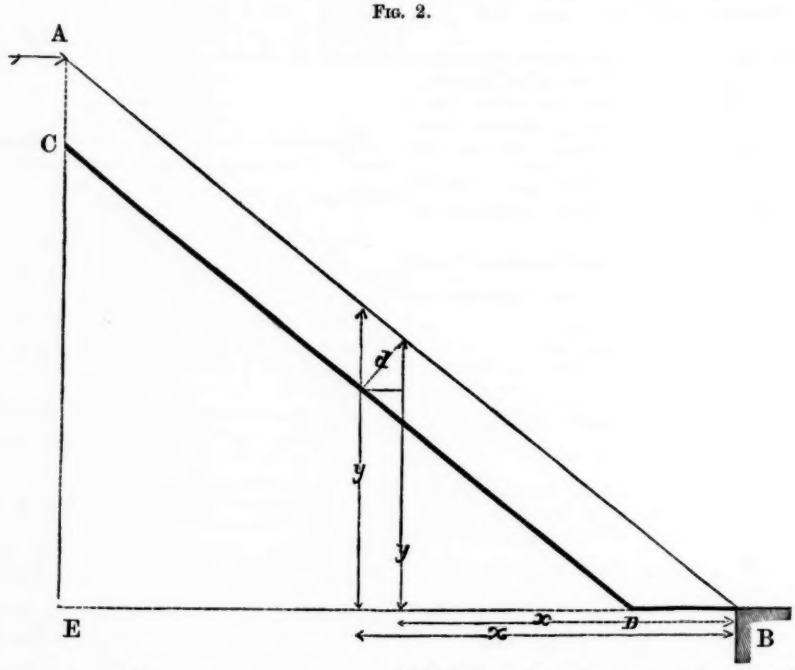
Taking moments around A, we have the moment of the reaction of the wall, $\frac{w\,s}{4}$, less the moment of the load on A B $\frac{w}{2} \cdot \frac{s}{4}$, which gives $\frac{w\,s}{8}$ for the moment of the horizontal reaction of the wall, and dividing by h we have $\frac{w\,s}{8\,h}$ for the amount of the horizontal reaction.

Taking a point in the lower flange, distant horizontally, x from the wall B, to obtain L, the longitudinal strain, in the upper flange at a place vertically over this point; we have,

$\frac{w\,x}{2}$ = the moment of the vertical reaction at B;

$\frac{w}{s} \times x \times \frac{x}{2} = \frac{w\,x^2}{2\,s}$ = the moment of the load on the part x;

FIG. 2.



$\frac{w\,s}{8\,h} \times \left(y - \frac{2\,d\,l}{s}\right)$ = the moment of the horizontal reaction at B; and

L d = the moment of the longitudinal strain in the upper flange;

Whence

$$\mathrm{L}\,d = \frac{w\,x}{2} - \frac{w\,x^2}{2\,s} - \frac{w\,s}{8h}\left(y - \frac{2\,d\,l}{s}\right) \qquad (3)$$

or

$$\mathrm{L} = \frac{w\,x}{2\,d} - \frac{w\,x^2}{2\,d\,s} - \frac{w\,s\,y}{8\,h\,d} + \frac{w\,l}{4\,h},$$

But

$y : x :: h : \frac{s}{2}$, or $\frac{y}{h} = \frac{2\,x}{s}$, and $\frac{w\,s\,y}{8\,h\,d} = \frac{w\,x}{4\,d}$

And

$$\therefore \mathrm{L} = \frac{w\,x}{4\,d} = \frac{w\,x^2}{2\,d\,s} + \frac{w\,l}{4\,p} \qquad (4)$$

Taking the moments around a point in the upper flange vertically above the point last taken, we have

$$\mathrm{L} = \frac{w\,x}{2\,d} - \frac{w\,x^2}{2\,d\,s} - \frac{w\,s\,y}{8\,h\,d},$$

and as

$$\frac{y}{h} = \frac{2\,x}{s},$$

$$\therefore \mathrm{L} = \frac{w\,x}{4\,d} - \frac{w\,x^2}{2\,d\,s} \qquad (5)$$

A strain differing from that in the upper flange in character, being tension while the other is compression, and in amount by the constant quantity, $\frac{w\,l}{4\,h}$.

In equation (4) L, the longitudinal strain in the upper flange, is greatest when $x = \frac{s}{4}$ or at the centre of the rafter.

When $x = 0$ or $\frac{s}{2}$, L or the longitudinal strain at B or A becomes $\frac{w\,l}{4\,h}$.

If there be any vertical strain passing through a or x, it would not appear in any of the previous equations because it would have no moment; but by taking moments outside of the vertical line passing through x, we can ascertain the amount of the vertical strain.

Let any point b be taken, but for simplicity let it be in the lower flange in a line perpendicular at a to A B. Let x' be its horizontal distance from the wall B, and $y' - \frac{2\,d\,l}{s}$ its vertical height above the wall.

Then, moment of vertical reaction of the wall $= \frac{w\,x'}{2}$.

Moment of horizontal reaction of the wall $= \frac{w\,s}{8\,h}\left(y' - \frac{2\,d\,i}{s}\right)$.

Moment of the load on a B $=$

$$\frac{w\,x}{s}\left(\frac{2\,x'-x}{2}\right),$$

Let L′ be the longitudinal strain at a, as found from these moments, then,

$$L'\,d = \frac{w\,x'}{2} - \frac{w\,x'\,x}{s} - \frac{w\,x^2}{2\,s} - \frac{w\,s\,y'}{8\,h} + \frac{w\,d\,l}{4\,h}$$

And since

$$\frac{y'}{h} = \frac{2\,x'}{s},$$

$$L' = \frac{w\,x'}{4\,d} - \frac{w\,x'\,x}{d\,s} + \frac{w\,x^2}{2\,d\,s} + \frac{w\,l}{4\,h} \qquad (6)$$

Since L′ and L are the longitudinal strains which meet at a, and as one is greater than the other, their difference can be contained only in the vertical through a. It plainly follows that the moment of that difference is equal to the moment of the vertical force through a or x.

Let V $=$ the vertical force, then its moment is V $(x'-x)$.

And as $(L'-L)\,d$ is the moment of the difference of the longitudinal strains, therefore

$$(L'-L)\,d = V\,(x'-x) \text{ or } V = L'-L\left(\frac{d}{x'-x}\right);$$

From equations (4) and (6)

$$L'-L = \frac{w}{4\,d}\,(x'-x) - \frac{w\,x}{d\,s}\,(x'-x).$$

Multiplying by $\frac{d}{x'-x}$, (7)

$$V = \frac{w}{4} - \frac{w\,x}{s}$$

The vertical strain in the web of the rafter. When x in this equation equals $\frac{s}{4}$, V $= 0$; and V reaches its maximum when x equals $\frac{s}{2}$, or when $x = 0$, for in either case it is equal to $\frac{w}{4}$. The minus sign in this equation indicates, as it did in the examples of the horizontal girders, the weight going towards the abutment opposite to the one from which x is measured. In this case V has no value at the centre of the rafter and beyond towards the ridge, the weight passes towards the opposite rafter.

In the previous investigation of strains in horizontal girders, it was shown that the horizontal strains became zero at the ends of the girders, and we, consequently, had only the vertical force acting upon the abutments. Considering a rafter as a single girder, the longitudinal strain

$$L = \frac{w\,x}{4\,d} - \frac{w\,x^2}{2\,d\,s} + \frac{w\,l}{4h},$$

does not become zero at either end, for making $x = \frac{s}{2}$ or 0,

$$L = \frac{w\,l}{4\,h}.$$

Consequently in addition to the vertical strain of $\frac{w}{4}$ at the ends of the rafter, we have a longitudinal strain of $\frac{w\,l}{4\,h}$ thrusting upward at the ridge and downward at the wall.

We can resolve $\frac{w\,l}{4\,h}$ into vertical and horizontal components by the following proportions:

$l : h :: \frac{w\,l}{4\,h} : \frac{w}{4}$, the vertical component.

$l : \frac{s}{2} :: \frac{w\,l}{4\,h} : \frac{w\,s}{8\,h}$, the horizontal component.

The first being equal to the value of V at the ridge, and opposite to it, is neutralized by it, leaving only a horizontal force thrusting against the other rafter. At the wall where V again is equal to the vertical component of $\frac{w\,l}{4\,h}$, they act in the same direction, downwards, with a vertical force of $\frac{w}{2}$, while $\frac{w\,s}{8\,h}$ is the horizontal thrust against the wall.

$\frac{w\,l}{4\,h}$ being constant, its components are also constant, and to obtain the total vertical strain in a rafter, we have to add the vertical component $\frac{w}{4}$ to the vertical equation $\frac{w}{4} - \frac{w\,x}{s}$, and we obtain $\frac{w}{2} - \frac{w\,x}{s}$, an equation similar to that obtained for the horizontal girders, but which differs in being contained partly in the web and partly in one flange while the other was contained wholly in the web.

The upper flange is subject to compression, and the lower flange to tension, when the rafter is connected to the opposite rafter and to the wall by the upper flange. Joining the rafters to each other and to the wall by the lower flange, the longitudinal strain in the upper flange is by similar reasoning, $\frac{w\,x}{4\,d} - \frac{w\,x^2}{2\,d\,s}$, and in the lower flange,

$$\frac{w\,x}{4\,d} - \frac{w\,x^2}{2\,d\,s} - \frac{w\,l}{4\,h}. \qquad (8)$$

In this case $\frac{w\,l}{4\,h}$ represents compression, while the remainder of the equation represents tension, or, if values be substituted, when their result has the minus sign there is compression, when the plus sign there is tension.

$\frac{w\,l}{4\,h}$ is constant and independent of the value of d, while the rest of the equation varies with the value of d; when, therefore,

$$\frac{w\,x}{4\,d} - \frac{w\,x^2}{2\,d\,s} = \frac{w\,l}{4\,h},$$

we have a point where there is neither compression nor tension.

Let us give $\frac{w\,x}{4\,d} - \frac{w\,x^2}{2\,d\,s}$ its greatest value by making $x = \frac{s}{4}$ and we get $\frac{w\,s}{32\,d}$ at the centre of the rafter; making $\frac{w\,s}{32\,d} = \frac{w\,l}{4\,h}$, and we have neither compression nor tension at this point. But in this case d would become equal to $\frac{h\,s}{8\,l}$ or nearly $\frac{h}{4}$, an unnecessary depth. If the depth be less than $\frac{h\,s}{8\,l}$, then $\frac{w\,s}{32\,d}$ becomes greater than $\frac{w\,l}{4\,h}$, and the lower flange of the rafter is subject to tension in the centre and to the points on either side where $\frac{w\,x}{2\,d} - \frac{w\,x^2}{2\,d\,s} = \frac{w\,l}{4\,h}$ (where there is no strain) beyond there is compression, increasing to the end where it is $\frac{w\,l}{4\,h}$, to be resolved as before.

We have now obtained the longitudinal strains from the two flanges, where either one alone is united to the opposite rafter and the wall, and can obtain from the vertical force the strains on the members of the web, if the rafter be a truss regularly divided into panels; but it will be a simpler process to obtain the transverse strain, or strain at right angles to the rafter, and we shall then have two formulæ, corresponding to the horizontal and vertical formulæ, obtained in the cases of the horizontal girders; each formula representing a strain, no part of which is contained in the other.

The transverse strain can be obtained from the equation:

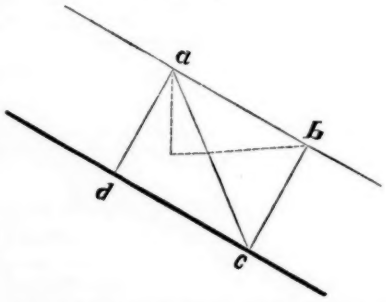
$$\mathrm{V} = \frac{w}{4} - \frac{w\,x}{s},$$

by the following proportion,

$$l : \frac{s}{2} :: \frac{w}{4} - \frac{w\,x}{s} : \frac{w\,s}{8\,l} - \frac{w\,x}{2\,l} \qquad (9)$$

This strain can likewise be obtained in the following manner:

FIG. 3.



Let $a\ b\ c\ d$ be a section of a rafter or inclined truss, joined to the other rafter and the wall by its upper flange, and x and x' the horizontal distances of a and d from the wall; $\frac{w\,x}{4\,d} - \frac{w\,x^2}{2\,d\,s} + \frac{w\,l}{4\,h}$ will be the longitudinal strain at a, and $\frac{w\,x'}{4\,d} - \frac{w\,x'^2}{2\,d\,s} + \frac{w\,l}{4\,h}$ will be the longitudinal strain at d. The difference has been united to a transverse strain or strain having a transverse component and has passed into the web or panel. This difference will bear the same proportion to $a\ d$ that the transverse strain united with it does to d, the depth of the rafter.

$\frac{s}{2} : l :: x - x' : \frac{2\,l\,(x-x')}{s}$ = the distance $a\ d$.

The difference of the two strains is

$$\frac{w}{4\,d}(x - x') - \frac{w}{d\,s}(x - x')\,\frac{(x+x')}{2}.$$

Then

$$\frac{2\,l\,(x-x')}{s} : d :: \frac{w}{4\,d}(x - x') - \frac{w}{d\,s},$$
$$(x - x')\,\frac{(x+x')}{2} : \frac{w\,s}{8\,l} - \frac{w}{2\,l}\,\frac{(x+x')}{2}.$$

Making $\frac{x + x'}{2} = u$, when $a\ d$ is considered indefinitely small, or when there is a panel, the distance to its centre; we have

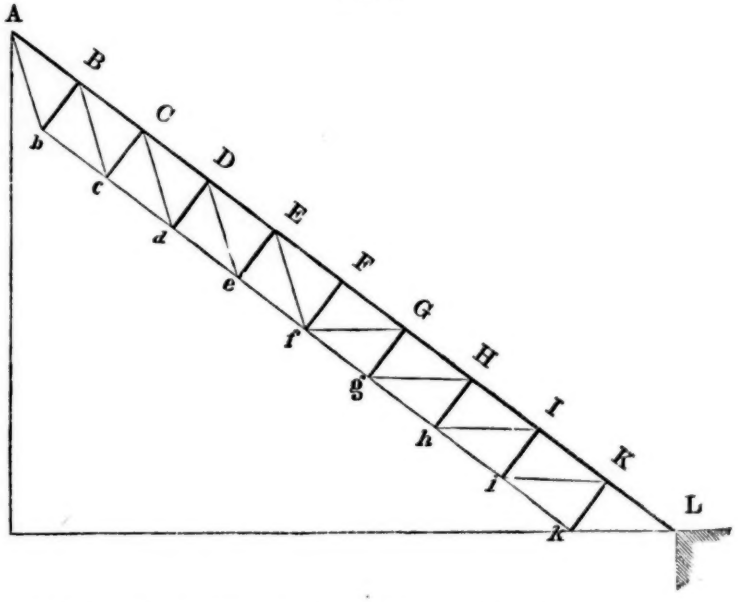
$$\frac{w\,s}{8\,l} - \frac{w\,u}{2\,l} \qquad (10)$$

for the transverse strain.

To make a practical application of the

formulæ obtained above, let figure (4) represent a rafter, trussed after the Howe system, and joined to the wall and to the opposite rafter by the upper chord.

FIG. 4.



Let $l = 125$ feet, the length of the rafter, from the ridge to the wall.
$s = 200$ feet, the span of the roof.
$h = 75$ feet, the height of the ridge above the wall.
$d = 6.25$ feet, the depth of the rafter.
$w = 100{,}000$ lbs. the weight uniformly distributed over the whole roof.
$x =$ the horizontal distance from the wall to the end of any panel in the chord connected to the wall and to the other rafter.
$u =$ the horizontal distance to the centre of any panel measured similarly to x
L = the longitudinal strain in either chord.
T = the transverse strain.

For the strains in the upper chord, we have equation (4).

$$L = \frac{w\,x}{4\,d} - \frac{w\,x^2}{2\,d} - \frac{w\,l}{4\,h}.$$

Substituting the values of the constants as given above, the equation becomes

$$L = 4000\,x - 40x^2 + 41666.$$

The first value of $x = 10$.
When L = 77667 lbs. Compression in K L and A B.
Next value of $x = 20$.
Whence L = 105667 lbs. Compression in I K and B C.
Next value of $x = 30$.
Whence L = 125667 lbs. Compression in H I and C D.
Next value of $x = 40$.
Whence L = 137667 lbs. Compression in G H and D E
Next value of $x = 50$.
Whence L = 141,667 lbs. Compression in F G and E F.

For the strains in the lower chords we have equation (5).

$$L = \frac{w\,x}{4\,d} - \frac{w\,x^2}{2\,d\,s}$$

Substituting constants as before,

$$L = 4000\,x - 40\,x^2.$$

When $x = 10$, L = 36000 lbs. Tension in $i\,k$ and $b\,c$.
When $x = 20$, L = 64000 lbs. Tension in $k\,i$ and $c\,d$.
When $x = 30$, L = 84000 lbs. Tension in $g\,h$ and $d\,e$.
When $x = 40$, L = 96000 lbs. Tension in $f\,g$ or $e\,f$.

It will be seen that L has the same value for points on either side of the centre of the rafter, equally distant therefrom; for instance, L is the same whether $x = 30$ or 70.

When x has a certain value, say 20, L is the longitudinal strain at I and i. To the right of I and to the left of i, there is but one member subject to the longitudinal strain. It is therefore the strain in this member which is determined by the equation. The equation also gives the strain on the other sides of these two points, but it is there divided between two members.

Proceeding with the calculation, we have for the transverse strain equation (10),

$$T = \frac{w\,s}{8\,i} - \frac{w\,u}{2\,i}.$$

Substituting constants, $T = 20000 - 400\,u$.

First value of $u = 5$, $T = 18000$ lbs. Compression in struts K k and B b.

There is the same strain in the ties k I and A b the longitudinal value of which is obtained by multiplying the transverse strain by the secant of the angle the tie makes with the strut 2.333.

Whence $18000 \times 2.333 = 42000$ lbs. Tension in k I and A b.

When $u = 15$, $T = 14000$ lbs. Compression in I i and C c.
$14{,}000 \times 2.333 = 32667$ lbs. Tension in i K and c B.

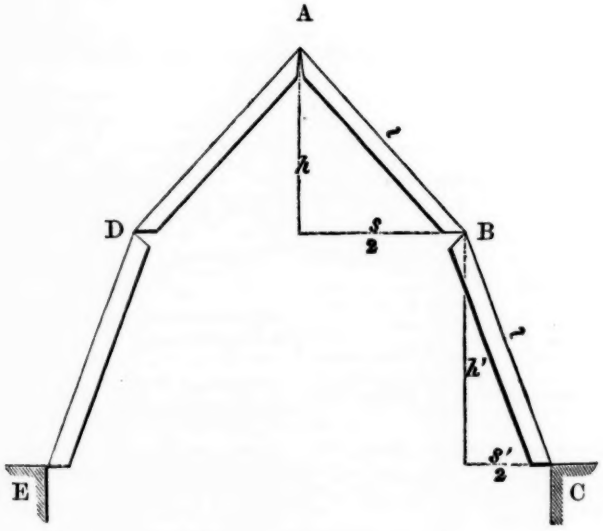
When $u = 25$, $T = 10000$ lbs. Compression in H h and D d.
$10000 \times 2.333 = 23333$ lbs. Tension in h I and d c.

When $u = 35$, $T = 6000$ lbs. Compression in G g and E e.
$6000 \times 2.333 = 14000$ lbs. Tension in g H and e D.

When $u = 45$, $T = 2000$ lbs. $\times 2 = 4000$. Compression in F f.
$2000 \times 2.333 = 4667$ lbs. Tension in f G and f E.

Now suppose the girder to be inverted so that $b\,k$ becomes the upper chord while A L is the lower chord joined to the opposite rafter and the wall. Let the struts become ties and the ties struts, equation

FIG. 5.



(8) will then apply to the lower flange and will give the following results:

A B and K L will suffer 5667 lbs. compression.
B C and I K will suffer 22333 lbs. tension.
C D and H I will suffer 42333 lbs. "
D E and G H will suffer 54333 lbs. "
E F and F G will suffer 58333 lbs. "

The chord $b\,k$ will suffer an amount of compression exactly equal to its tension when it was the lower chord.

In the same manner any other form of truss used for this purpose can be calculated, and the equations which were obtained for horizontal trusses can easily be adapted for similar rafters.

The resultant of the vertical force and

the horizontal force at the wall is not in a line with the rafter; for let the force $\frac{w}{2}$ be represented by h, then $\frac{w}{2} : \frac{w\,s}{8\,h} :: h : \frac{s}{4}$; or the resultant is the hypothenuse of a right-angled triangle, whose altitude is to h as its base is to $\frac{s}{4}$. This is true no matter what the weight may be, and if the roof is to be sustained by an inclined support, this gives the proper inclination.

If, however, this inclined support have weight of its own, and be in fact another rafter, and we are considering only the effects of the weights upon the rafters, then the inclination given above will be too great, because the weight of the lower rafter will increase the horizontal thrust and destroy the equilibrium of the roof.

To obtain the proper inclination, let Fig. 5 represent a roof of this kind.

h being the height of the ridge A above B, s the span A B and w the weight on D A B, $\frac{w\,s}{8\,h}$ is the horizontal thrust at A and B.

What shall be the inclination of B C, $\frac{w'}{2}$ being the weight it supports in addition to the weight from the rafter above, h' and $\frac{s'}{2}$ the vertical and horizontal distances between B and C? From two of these we can determine the third.

Taking moments around B we have the moment of the vertical reaction of the wall $= \left(\frac{w}{2} + \frac{w'}{2}\right)\frac{s'}{2}$. The moment of load on B C $= \frac{w'\,s'}{8}$, and the moment of the horizontal reaction of the wall $= \frac{w\,s\,h'}{8\,h}$. Whence,

$$\frac{w\,s'}{4\,h'} + \frac{w'\,s'}{4\,h'} - \frac{w'\,s'}{8\,h'} = \frac{w\,s}{8\,h}.$$

And

$$\left(w + \frac{w'}{2}\right)\frac{s'}{h'} = \frac{w\,s}{2\,h}.$$

We must give values to two of the quantities w', h', s', to obtain the third. Let for example $h' = h$, and we have

$$w + \frac{w'}{2} : \frac{w}{2} : : s : s'.$$

If $w = 100000$, $w' = 75000$ and $s = 200$ ft. s' will be 72 ft., and $\frac{s'}{2} = 36.4$ ft. In the same manner s' and w' being given, h' can be obtained.

WATER SUPPLY AND OTHER QUESTIONS IN INDIA.

From "The Builder."

The condition of the water supply in India has recently undergone a searching examination, and the results obtained are by no means satisfactory. The low-caste (or no-caste) natives of Bengal are not particular in the matter of water, and up to a very recent period Englishmen have thought far more of conquest than of sanitary regulations; so that the sources of water supply have been very little cared for. Tanks have accumulated vast masses of vegetation, and have abounded with fish and water-insect life. Wells, as a rule, have had no protection against surface pollution, and the results have been and are that both tanks and wells continue to be fearfully polluted, not only with vegetable and mineral matters in excess, but also with animal matter of the most revolting sort, namely, drowned bodies of natives. Any person conversant with Indian history knows that the poor Hindoo is a creature of impulse and despair; death has little of terror for a famine-stricken native, and suicide by drowning, even in tanks and wells known to be in use, is fearfully common, and human bodies are committed to the sacred waters of the Ganges in countless numbers; and yet this water is used by the residents on its banks and even in Calcutta. In the Bengal Presidency, during one year, upwards of 1,200 human bodies have been removed from tanks and wells, the water of which tanks and wells is in use as a supply for towns, villages, stations, barracks, hospitals, etc., and on cleansing some of these wells, many human bones have been removed, the flesh having wasted (dissolved) away. At many of the stations in this Presidency, Europeans on their first arrival suffer in various ways; as by fever, diarhœa, and cholera, by boils, and by entozoa and intestinal worms; regiment after regiment, as the men have arrived, going through this disgusting routine of

drinking tainted water and paying the penalty in human sufferings. Recent chemical analyses show that a vast proportion of these diseases is preventable. The Presidency of Bengal is a region of heat, moisture, rivers, swamps, jungle, and cholera; and it is in this vast district that this dreaded disease (cholera) obtains its birth, and, in its terrible maturity and strength, passes forth over the inhabited parts of the earth to teach men that they must pay the penalty of a sudden and loathsome death if the simple laws of nature are neglected, or are blindly and selfishly broken. It has long been known that polluted water is, during epidemic periods, a deadly poison; and if water pollution and cholera are cause and effect, the tainted wells and tanks of Bengal only perform their natural work. The preparations and the results are in accord. Tanks and wells are neglected; and, consequently, are polluted to the uttermost; the population, native and European, blindly and ignorantly drink the waters and suffer accordingly. From the grand ranges of the vast snow-capped Himalayan mountains to the sea, over the regions watered by the sacred Ganges and its numerous tributaries, this neglect prevails. The monsoons bring deluging rains and relief, for as the waters rise cholera disappears, being drowned out of the submerged swamps and vast alluvial plains, but only to reappear on the subsidence of the great flood waters, as the tropical heat evaporates the sodden soil and rotting vegetation. The mortality in such a district, so neglected, has been very great. The questions now are, "Need such mortality continue?" "Must European life be expended at the rate common to periods which have passed?" On the nature of the answers to these questions depends the supremacy of British power in India for a shorter or a longer period. Sanitary science teaches this lesson. Abandon stations situated in swamps and jungles; cleanse and protect all sources of water supply, and establish a sanitary police both for the native and for the British populations; remove every known cause of disease which is removable; wash and be clean; but see that the water is free from pollution. The continued government of India by Europeans cannot be. Great Britain may plant her pure religion, her civil law, and her sanitary order; but she will not govern in perpetuity. She may devise canals, tanks, and wells furnishing pure water, and construct net-works of highways and roads, common and iron; foster native manufactures, and encourage commerce; but in due time her work will have been accomplished and her labors must cease. In the future history of the world the facts and incidents connected with British power in India most dwelt upon will not be of armies, generals, governors, and conquests; of battles, suppressions of mutiny, or of human slaughter in any form. The memory of these may remain, breeding feelings of revenge, or of shame, or of sorrow, in proportion as the hearts of those who read are hardened, or have been civilized by Christian teaching. The true and enduring fame of Great Britain will be connected with the permanent establishment of works and regulations of the most simple character, namely, those works which have tended to promote social comfort, and those regulations which have best insured human happiness, and are a means of securing health to the greatest numbers.

J. J. Smith and T. Eastwood have patented an improved working valve of steam-engines. The eccentric rods are attached to an oscillating bar having a slot in the centre thereof, through which a pin attached to the valve spindle is passed. The oscillating bar works in and imparts its motion to a "compensating bar" contained within the fork of the valve spindle, the pin attaching the parts together also passing through the box. Wedges are inserted between the ends of the oscillating bar and the compensating box to take up or compensate for any wear that may occur by reason of the friction or lamination of the surfaces.

A new furnace has been erected at the Franklin Iron works in Oneida county, N. Y., and is now in blast. It has a diameter of 14 ft. at the bosh, and a height of 54 ft. It is yielding 25 tons of No. 1 iron per day upon a consumption of 1 ton 5 cwt. of coal.

The capital stock of the Altman Miller Co., at Akron, O., has been increased to $300,000.

HEATING BUILDINGS BY HOT WATER.

From "The Mechanics' Magazine."

The proverbially fickle climate of the British islands, and the frequent recurrence of a damp and cold atmosphere, make the application of artificial heat to our dwellings and public buildings a positive necessity. Contrivances for producing an equable temperature within doors are consequently numerous, and in many instances they are of an ingenious character. Perhaps the best mode of accomplishing the desired end, as well as the simplest, is that of causing the circulation of hot water through iron pipes conveniently disposed for the purpose. Up to a very recent period, however, a considerable amount of hostile prejudice existed in regard to the use of hot water apparatus, and even now the plan of heating buildings by such agencies is not fully appreciated. Imagining that antipathy to the system arises in many cases from a lack of acquaintance with its peculiar merits, we shall endeavor to explain the principles which govern the action of hot water apparatus generally, and furnish some information as to their best form and proportions. In order to do this effectually, we must first glance at one or two of the natural laws which affect the circulation of fluids and gases. That all falling bodies gravitate with the same velocity, and therefore descend through a certain definite space in a given time, is an effect of which gravity is the cause. It is from this cause that we obtain the unerring action of the pendulum. To the same source may be distinctly traced the phenomena attending the circulation of hot water through pipes, and this circulation, once created, forces all the water in the apparatus to pass successively through the boiler by which it is primarily heated. It is upon the continuous and uniform movement of the water along the pipes that the efficiency of the hot water apparatus immediately depends. Let us, then, inquire as to the power which insures this vitality, for without a clear perception of its nature there will ever be uncertainty as to the working of any apparatus of the kind in question. The force which produces circulation arises from the fact that the water in the descending pipe is heavier than that which is in the boiler, or, to put it differently, when heat is applied to the boiler a dilatation of the water within it ensues. The heated particles ascend through the colder ones, whilst the latter descend by reason of their greater specific gravity and in turn become also heated. Expansion follows, and this species of action and reaction proceeds until all the particles are equally heated. It follows that the colder the water is in the descending pipe, relatively with that in the boiler, the more rapid will be its motion through the circulating pipes, and hence the diffusion of heat through their pores and into the atmosphere surrounding them.

Thus much of the general principles which control the action of hot water apparatus as applied to the heating of buildings, and now as to their particular dimensions and details. These will naturally have to be varied with the character and size of the buildings to be heated. For churches and large structures of a similar kind, and which have an ordinary number of doors and windows, it will be necessary in devising hot water apparatus to ascertain, first, the cubic contents of the auditorium. Having obtained this knowledge, let the number gained be divided by 200. The quotient will yield the length in feet of 4 in. pipe required to maintain something like a steady temperature of 55 deg. For smaller apartments, as, for example, dwelling-houses, etc., the cubic measurement divided by 150 will furnish the proper length of 4 in. pipe. These simple rules, which are the result of extensive practice and careful observation, may be safely relied upon, unless under very exceptional circumstances, and which, of course, would have to be duly considered by the constructor of an apparatus intended to meet them.

In reference to greenhouses, conservatories, and buildings of a like character, where the temperature should reach a mean of 60 deg., the sum of the cubic contents divided by 30 will give the length in feet of 4 in. pipe required to produce the desired effect. Forcing houses, again, must have special calculations made for properly heating them. Nothing short of a uniform temperature of 70 deg. to 75

deg. will suffice for such places. In order to insure this the measurement, as before suggested, must be divided by 20, the quotient being the length of circulating pipe required. For gaining yet higher temperatures, lower divisors will have to be employed, and if smaller pipes be determined upon, the length must be proportionately increased. These are points of detail, however, which may be safely left to the skilled manufacturer who may be intrusted with the making of hot water apparatus for special purposes. Our own data may be taken as the base of calculations for economically and effectually heating buildings by means of hot water.

We are aware that some horticulturists have adopted the plan of heating their forcing houses to a much higher temperature than that indicated above, and of allowing a greater amount of ventilation than is usual. By aid of such arrangements, it is said, a finer fruitage is obtained, but there is no doubt that this course involves increased expense in the first cost of the heating apparatus, together with a large augmentation in the subsequent daily consumption of fuel for working it.

An important consideration to the horticulturist and floriculturist is the waste of heat through glass roofs and walls. It has been found, from a course of carefully made experiments, that one square foot of glass will cool 1.279 cubic feet of air as many degrees per minute as the internal temperature of the house exceeds the external temperature. Thus, if the difference between the internal and the external temperature be 30 deg., 1.279 cubic ft. of air will be cooled 30 deg. by each sq. foot of glass in the building which is exposed also to the outer atmosphere. It will be admitted that this fact should be allowed its due weight in contriving hot water apparatuses for houses wholly or partly constructed of glass. Of course, in estimating the area of glass, due deductions must be made for the sash frames and wood-work by which the panes are surrounded. If the frames and sashes be made of metal, the radiation and consequent loss of heat through them will be equal in extent to that which results from the glass itself.

The quantity of air to be heated per minute, so far as conservatories and forcing houses are concerned, should not be less than $1\frac{1}{4}$ cubic ft. for each sq. foot of glass which the building contains. When the quantity of heated air required has been thus ascertained, the length of pipe may be determined by the following formula, viz. :—Multiply 125 by the difference between the temperature at which the house is proposed to be kept (when at its maximum) and the temperature of the external air, and divide the product by the difference between the temperature of the pipes (200 deg.) and the proposed temperature of the room. Then the quotient multiplied by the number of cubic ft. of air to be heated per min., and its product divided by 222, will give the number of ft. of 4 in. pipe to yield the desired effect.

Although our remarks on this subject have extended beyond the limits originally intended, a word or two must be said as to the quality of the water to be used for heating purposes. Sometimes foul water is employed, under the impression that anything will do for the hot water apparatus. This is a grievous error, for the result will be the deposit of a coating of mud or other material throughout the pipes, thus impairing their radiating action and efficiency. The boiler, too, will suffer if it be not eventually destroyed by such a neglect of ordinary precautions. When saline matter occurs in a boiler, obviously damage to it and waste of fuel must be the consequence. The sediment can only be removed with difficulty. A weak solution of muriatic acid will assist in effecting its dispersion. Rain water is better adapted for use in heating apparatuses than water of any other kind, and when obtainable, therefore, it should always be employed. When an apparatus is disused for a time and left with water standing in the pipes, there is danger of the latter freezing. Possibly the pipes may burst under such circumstances. It is a wise precaution, therefore, to leave the pipes either entirely or partially empty, when the apparatus is not likely to be put into action for any length of time. With ordinary care the hot water apparatus may be made to last—if originally well constructed—for very many years. It is really an economical application of science to the practical wants of daily life, and we predicate for it a widely extended field of usefulness when its advantages are more

completely understood. In London there are several very successful constructors of apparatus for heating buildings, but it would be invidious to particularize them. Our object is to attract the attention of those interested to a branch of economic science which has hitherto obtained far too little public notice.

THE TAJ-MAHAL AT AGRA.*

From "The Builder."

During a stay of three or four years in the East, one meets with so much worth describing that on being asked by friends in the cold civilized West what one has seen, it is sometimes a difficult matter to know what people, countries, customs, or buildings to tell about first; but in the spring of last year it was my good fortune to find myself in the cities of the old Moguls—Agra and Delhi—and of all places I have been to, either in the West or East, I unhesitatingly affirm that Agra and the Taj-Mahal stand pre-eminent in the impression made on my mind.

Venice, with its Grand Canal and St. Mark's, numerous palaces and art works; Constantinople and the Bosphorus, with the Sta. Sophia and Sulieman Mosques; Cairo, with its beautiful Hassan and interesting Tooloun Mosques, picturesque streets, and Coptic churches and ruins, and the huge ugly pyramids; and Bejapore, with its big dome and elaborate Ebrahim Roza, all fall into the shade contrasted with Agra and its Taj-Mahal. Its romantic situation, dazzling brilliancy, excessive elaboration, and the particularly refined, though lavish display of wealth in its ornamentation, make it beyond all others a place in which a cold-blooded Caucasian can perhaps realize somewhat of the poetical and luxurious feeling of the voluptuous Easterns.

The Taj-Mahal was built about the year 1040 of the Hijree, or 1662 A. D., about the time of the Restoration, and during the latter years of the reign of Kurreem Shah, the fifth of the Mogul Emperors, grandson of the great Akbar, and son of Jehangir. He is more commonly known by his assumed title of Shah Jehan, signifying the King of Worlds. It was erected as a tomb for his wife, the Begum, Ungeman Bunnoo, whose title was Moomtaz Mahal, daughter of Azif Khan, and granddaughter of the Nawab Ettmadowla. She was also called Taj-Mahal, and Noor-Mahal, which means the Light of the Hareem or Palace. She is immortalized in our own language in Moore's beautiful poem of "Lalla Rookh." She had four sons and four daughters; the youngest daughter's name was Dhahur Arra, at whose birth Taj-Mahal died. Shah Jehan was exceedingly fond of her, and on her death-bed he promised two things, first, "That he would never marry again;" and, second, that he would build for her so magnificent a tomb that it should surpass all others the world ever saw.

The tomb is erected on the left bank of the river Jumna, and Shah Jehan's intention was to have erected another for himself of equal splendor on the opposite bank, connecting the two by a bridge with silver railings, so that after death their souls might be enabled to hold spiritual communion with each other. He went so far as to put in the foundations of the second, when his demise put a stop to further proceedings, and he lies, in consequence, by the side of his wife in her tomb, her sarcophagus occupying the centre position.

The Taj buildings altogether form a parallelogram. They consist of the Taj proper, placed on a raised dais of white marble, some 20 ft. high and 300 ft. square, situated in the centre of the end of the parallelogram immediately overlooking the Jumna, and flanked on each side by red sandstone buildings, separated from the raised dais by courts about 400 ft. wide, paved with marbles laid in geometrical patterns. One of these buildings is a mosque, the other is of no use but for its architectural effect in contrasting and grouping with the Taj, and is called by the natives the Jawab, which means "answer," and I think very well describes its meaning and use. This mosque and Jawab are of red sandstone and white and black marbles, and inlaid with precious

* From a paper by Mr. W. Emerson, read at a recent meeting of the Royal Institute of British Architects.

stones, something similar in design to the entrance gateway I shall presently describe. On the floor of this Jawab are outlines of the dome and finials, and some other portions of the Taj, cut in the pavement for the men to work from.

As one drives into the outer court-yard, and pulls up opposite the grand entrance, the beauty and magnificence of the place immediately strike one. The gateway is two stories in height; in elevation, it has a large and deep central recess, a semi-octagon on plan, domed over and flanked on either side by two smaller recesses, those on the upper floors forming galleries, and with large octagonal turrets at the extreme angle surmounted by domes supported on columns and arches. The grand centre arch is also surmounted by a row of 11 little domes on columns and arches, and flanked by slender minarets; the effect of these is particularly beautiful. It is built of red sandstone, inlaid with white and black marbles. The spandrels over the arches are of white marble, inlaid with semi-precious stones in the same manner as the tomb itself, only the work is of much larger design and rougher execution. The gateway forms a square room with large entrance arches on two sides, the outside one being hung with gates, and on the two other sides smaller doorways leading to rooms on either side, and to a staircase which leads to the galleries over these smaller rooms. A seat runs round the room, and on one side is a platform for the use of servants, soldiers, and gatekeepers. The lower part of the wall has a dado, formed of panels of white marble, enclosed by a border of inlaid white and black marble in a zig-zag pattern. Over and at the sides of the smaller side-doors are the peculiar little arched recesses used for placing lamps in at the time of a festival. The friezes are inlaid with sentences from the Koran. This gateway is domed over, faced internally with white choonam (or plaster) and ornamented with black lines, radiating from the centre, which accentuate the raised ridges dividing the little hollowed spaces, forming the surface ornamentation of the interior of the dome. The gates themselves are of teak, covered with a plating of bronze, with a raised pattern on it, in shape a mixture of a quatrefoil and rectilinear figure. Through this gateway, at the end of a long avenue of cypress trees, the centre of the avenue being occupied by marble fountains, basins, and flower beds, the Taj-Mahal, dazzling the eyes with its whiteness, is seen. On walking up the avenue and through the gardens, I could not help feeling it to be a more beautiful place than I ever dreamed of. There is almost every description and variety of flower, and on a hot day the cool sound of the water trickling along the little aqueducts which carry it to all parts of the grounds, the shady walks, and parts of the paths arched over by creepers, covered with flowers of most gorgeous colors, and the mango, guava, orange, lime and loquat trees, combine to make it a most pleasant resort. Leaving the gardens, and ascending a flight of marble steps and crossing the platform of white marble which in the bright sun dazzles the eyes so as to make them water copiously, and with "Salaam Sahib, Salaam Sahib," from the old Mussulman priests at the entrance, one finds one's self in the inside of the Taj itself.

The contrast between the bright light outside and the solemn gloom inside is so great, that for some minutes you can see nothing. Gradually this wears off, and one sees tolerably well, though to do drawings inside I was often obliged to get natives to hold candles for me. The plan is an irregular octagon outside, while the centre room is a regular octagon, recessed on each side, and about 60 ft. in diameter, and 80 ft. in height, with circular rooms in each angle of the building, connected by passages running all round the centre apartment. Under this centre apartment is a crypt or small chamber, in which are the sarcophagi that really contain the bodies of Shah Jehan and Taj-Mahal. The centre portion of the inner apartment is screened off and contains the show tombs, on which the natives strew flowers, etc.

The way in which light is obtained through the outer chambers and double walls, there being in no case a direct light into the principal room, and what does enter being broken by the trellis work that fills the openings, causes a wonderfully cool and solemn effect on first entering. At each corner of the raised dais on which the tomb is placed are minarets.

The building is two stories high, the centre room running up the whole height of both stories. Access can also be had to the roof, which is flat, and has four

smaller domes supported on piers and arches, one over each corner circular apartment. The centre chamber is surmounted by a double dome—the one forming the ceiling being about 80 ft. from the ground, and the upper one being about 260 ft. high, and is the principal feature in a distant view of the Taj group. The external elevation of the four principal sides is the same, also the four angle fronts are the same design. The arrangement of these façades is very simple. The principal ones are divided into three parts. In the centre part is a large, well-proportioned, recessed entrance arch, the height of the two stories, and surmounted by a parapet and two minarets, which being carried down to the ground as slender octagonal shafts, form the division between the main central recessed portion and the smaller parts which flank it. These side parts of principal elevations have two arched recesses much smaller than the central one, placed one over the other, and forming the two stories in height, and are exactly similar to angle elevations, being again divided from them by minarets as before described. All these recesses are square on plan, and have at back arched and square-headed openings, which are fitted with the marble trellis-work for admission of light The domes, which are over the four angles, are supported by piers and arches, the arches being foiled after the Saracenic fashion. The domes spring from a cornice formed of plain projecting slabs of marble, supported by cantilevers.

In the centre rises the huge bulbous dome, which forms the grand central feature of the Taj. It springs from a plain straight circular shaft, which rises to about the height of the tops of smaller domes. A plain twisted bead mould marks the springing. The peculiarity of this and other Musselman domes in India is the bulbous shape obtained by making them swell out considerably beyond the springing line. This form obtains at Bejapore to a great extent. This dome is topped by a huge gilded finial with a golden crescent. The walls are mainly built of red sandstone, but completely encased with white marble. This is not done in the veneering fashion of Italy and Egypt. Each slab of marble is 4, 6, or even 8 in. in tnickness. In the construction of the dome, and other places where it would not interfere with the after ornamentation, it is built up with the walls, laying first a course as slabs of flat masonry, and then a course on edge, thereby obtaining good bond, and an external effect of alternate broad and narrow courses of about 18 in. and 4 in. in depth, so that riveting was never needed.

This method obtained in many places in India, where their building stone was wedged out of the quarries in large flat slabs. About Agra and Delhi all the buildings, whether of red sandstone or marble, were done in this manner; the interior of the walls was filled in with rubble.

Were it not for the elaborate inlaid work, which partakes more of the nature of jewelry than architecture, this building would be the simplest in the world, but very effective, nevertheless — first, of course, owing to its grouping and proportion. Then its large broad plain surfaces are undisturbed in their repose by any projecting mouldings, while the cool delicate shadows in the large arched recesses cause quite a sufficient balance between the light and shade. The spandrels to arches and the illuminated surfaces are, as a rule, set back about an inch. The plinth projects about an inch, and a slender string, projecting very slightly, accentuates the parapet. I think these, with the bead round the springing of the large dome, and cornices of smaller domes, and the leaves at the apex, are the only particular lines formed by shade throughout the whole external face of the building.

One thing that lends a most peculiar charm to this tomb, is the wonderful delicacy of the shadows caused by the strong reflected lights. The pavement of the raised dais being all white marble, it reflects in so powerful a manner that it reduces the depth of all the shadows by quite a half, if not by more.

One general feature in the ornamentation of the Taj is the inlaid black marble. Every angle, arch, panel, recess, in fact the outline of each component part, is marked by lines of black marble, either 1, 2, 3, or more inches in breadth, according to the size or importance of the detail requiring accentuation. This, of course, accounts in a great measure for the absence of any mouldings, and I am inclined to think this method of ornamenta-

tion, or, more properly, accentuation, disturbs the grand repose of a building much less than any other method employing shade as the means.

Probably the greatest ornaments to, and most perfect pieces of work in connection with the Taj, are the four minarets at the corners. They are about 200 ft. high, and about 20 ft. in diameter at the base; but the proportion of these is so subtle, that the slightest alteration, by either increasing or decreasing the diameter, or taper, or height, one feels would immediately spoil their effect. They are most elegant, but have not the starved appearance of the minarets of Egypt, Constantinople, and Delhi. They are three stages in height. At each stage a light balcony, supported on cantilevers, running round the tower, and they are surmounted by domes on gilt columns, and foiled Saracenic arches and gilt finials. Winding stairs take one to the summit, to which stairs access is obtained by means of square-headed doors.

I mentioned before that each course of white marble is divided by a narrow course of black, which in the distance gives an appearance of very thick joints, and makes the circular shaft tell out wonderfully in perspective.

The mausoleum itself is ornamented to a height of about 6 ft., with panels, forming a sort of dado, edged with a border of inlaid work in semi-precious stones of various colors, and each panel being carved in relief with flowers growing out of pots—the lotus, rose, etc. The carving of these is very beautiful, finished as finely and as polished in every little detail as any Italian work, and with all the freshness of design and arrangement of Mediæval art. Around the arches the Koran is illuminated in black marble. In this manner, it is said, the whole Koran is inscribed on the Taj walls. The spandrels of the arches are inlaid with a flowing ornament of graceful design, in semi-precious stones. The angle shafts, forming minarets, have zig-zag lines inlaid in black marble. Under the parapets is a running pattern, also inlaid; and in the parapet itself is an inlaid pattern of bold design, in colored stones.

The interior is, in the same manner as the outside, ornamented with a carved and inlaid dado; but the carving is richer, and the inlaying more elaborate.

The dome, which is very dark, is covered all over with the pattern peculiar to Indian Mussulman architecture, which is formed by lines radiating from the centre, crosswise, and the spaces thus formed (which, of course, increases in size as the lines approach the springing of the dome) are hollowed; by this means the radiating lines are in reality formed by the ridges dividing the hollowed spaces. This is often elaborated to such an extent that it is impossible for the eye to follow the pattern.

I now come to the part of the building which is the most wonderful and elaborate part of it all, namely, the tombs and the screen enclosing them, all of purest white marble. The screen encloses an octagonal space. Each side of the octagon is divided into three bays; the centre bay of the side facing the entrance door is an archway into the enclosure; all the other bays are like to each other, and of similar design to the part at the side of the arch. At each angle and between each bay, are posts supporting perforated screens, each of a single slab of marble. It is very Italian in feeling. An eighth portion of it contains the whole design; this is reversed and turned upside down to form the whole screen. It is, I should think, the most elaborate piece of marble perforation in the world, and is polished all over; both sides are finished alike. The screens are surmounted with a sort of balustrade of carved and inlaid work.

But the most extraordinary part is the inlaid work on the pure white marble posts, rails, arch, and tombs. The tombs, both in the enclosure and in the crypt below, are simple parallelograms about 2 ft. high, with a small sarcophagus in the centre of each, on a plinth formed of two cymatium members, and fillets, and the top slab having an ogee mould.

The inlaid work is most elaborate, representing all sorts of flowers, worked in semi-precious stones—the stones carefully picked for each particular leaf, so that all shading and drawing of leaves is obtained by the graduated natural color or marks in the stones themselves. At the side of the central tomb is the following inscription, in Persian:—"The splendid tomb of Unjeman Bunnoo Begum, whose title was Moomtaz Mahal, was made in 1040 of the Hijree," and on the side of the other is:—"The magnificent

tomb of the king, inhabitant of the two heavens, Ridwan and Khool, the most sublime sitter on the throne of Illeeyn (*i. e.*, starry heavens), dweller in Firdoos (*i. e.*, Paradise), Shah Jehan Badsha Gazee, peace to his remains, heaven is for him. His death took place the 26th day of Rujub, in the year 1076 of the Hijree. From this transitory world eternity has carried him off to the next."

In some of the roses, which are no bigger than a franc, there are 30 pieces of stone, and the jointing is generally scarcely visible. It is, in fact, jewelry. Indeed, in the centres of the flowers on the head of the tomb there were originally large emeralds and rubies, but these were stolen during the Maharatta wars. The ornament is in some places of a flowing pattern ; in others, like little trees in full bloom, with magnificent flowers. The colors of the stones are arranged with such taste, and the effect is so quiet, that it is only after looking about for some time that one finds out what it is that gives the interior such a rich appearance. Not a single flower forces itself unduly on the eyes, and I have seen Europeans walk for the first time into the Taj, and go all round and out again, without ever noticing anything particular in the ornamentation of this screen and tombs. What they do notice at once is the soft echoing of every little sound. A musical note echoes and re-echoes through the dome, gradually and softly dying away. The natives believe these voices to belong to the unseen heavenly bodies, who watch over Noor Jehan and her husband. The most delicious harmony I ever heard was some singing by ladies in this tomb. The interior has the most solemn effect on one's mind—there is an amount of pathos in it that causes feelings in a sensitive person much the same as reading an affecting melancholy love-story, so much so that it almost forces tears to one's eyes.

The whole cost is said to have been about three millions of our money. It took 17 years in building, and the labor was all forced—the workmen being kept on a daily allowance of rice. Orientals say it was built by one Isa Mahmoud, an architect sent from Turkey to Shah Jehan for the purpose. Others say a man named Austin de Bordeaux, a French architect, designed it. As to whether purely Oriental, or in some measure European, I should be afraid to give a decided opinion. I think there is much of Italian feeling in the screen, and also in the four minarets and some details of the cantilevers. But then at Bejapore, and other places in India, I thought the same with regard to many details, and no one seems to doubt that the art of Bejapore is purely Oriental. Still it is possible that Italian artists may have had something to do with it in detail ; and I believe in some old manuscript accounts, mention is made of payments to a foreign artist. But this may have alluded to Isa Mahmoud, or Persian artists. It was built at a time when Italians were to be found all over the world, fleeing from ducal tyranny, and some may have found their way into the centre of India ; and they could have ingratiated themselves in no more favorable manner with the luxurious Mogul Emperors than by assistance in the art of magnificent building.

RIVAL GUN-CARRIAGES.

From "The London Times."

When an invention appears before the world ready for adoption everybody wonders at its simplicity, and asks, with surprise, "How is it we never thought of it before?" Such was the case with the Moncrieff carriage, which had cost the inventor 10 years to work out. The idea of using the force of recoil to raise another gun, or a weight that might in its turn lift the piece which had raised it, was by no means new. It had been tried many a time, and had always failed. But the manner of doing it and the success were new. The difficulty of the problem has been brought home to the minds of all by the trial of another apparatus at Woolwich, a sort of rival to that of Moncrieff. It was built according to an idea of Capt. Grant, inventor of the well-known field kitchen. The Royal Carriage Department had worked out his proposal. Yet, with all the talent of the inventor,

with all the assistance of experienced officials who have had Moncrieff's invention continually before them, the arrangements were manifestly imperfect, and the result was a failure.

The gun used for the experiment was a 7-in. breech-loading Armstrong. Together with its carriage it weighed about 5 tons. The carriage was placed on an inclined slide, consisting of two large side beams connected by cross pieces. The raised end of the platform was supported on heavy beams of wood, and underneath all was a platform very similar to the slide above, and mounted on trucks which ran upon curved iron racers or rails. The appearance of the whole was that of two right-angled triangles of heavy wood with their longest sides uppermost, the triangles being connected by cross beams of wood. Heavy chains were attached to the carriage, led over strong rollers at the highest angles of the apparatus, and then fastened to a counterpoise, weighing 6 tons. The counterpoise slid down the lower surface of the incline, being held from falling by grooves in which it moved. Some of the friction was saved by small rollers on the upper part of the counterpoise, and because it is well known that to impart sudden motion to a heavy body causes a great shock, unless that body be freely suspended. Strong india-rubber springs or buffers were placed where the chain was attached to the carriage, and also where it was fastened to the counterpoise. The apparatus was simple enough, but a glance was enough to show any one at all accustomed to such matters that the strain must be tremendous.

To explain simply the difference in general principle between the Moncrieff method of storing up recoil and this one, we will give a familiar illustration, putting aside all the practical advantage obtained by the peculiar curve of the Moncrieff elevators or rockers, and all the disadvantage of the friction caused by gun-carriage and counterpoise in the new apparatus having to work in grooves.

Suppose that a great weight has to be lifted from the ground very suddenly, and with as little shock as possible, because it is advisable that your apparatus shall last a long time—two methods are offered to you.

One is a rope simply led over a pulley at the end of an inclined beam or frame, one end fastened to the weight, the other in your hand. The pull is, from the nature of the case, to be a sudden one, not slow and gradual. Will there not be a great shock to your arms, and a dangerously sudden and severe strain upon the rope, communicated also to the pulley, and through it to the inclined frame, tending to force it backwards in the direction in which your sudden pull operates? Will there not be a tendency in the whole frame-work to tear away the supports by which it is fastened to the ground? This is the new apparatus.

The second plan offered you is to have the weight fastened to one of the ends of a large rocker shaped like a half-moon, so that the weighted end is down and the other nearly perpendicular above it. In this case your pull is to be applied to the upper end, and you have only to make the half-moon roll on its curved surface. Surely every one must feel at once, even without more knowledge of mechanism than nature has taught him, that in this case the weight will be moved with less strain upon the arms and with no danger of breaking or shifting anything from its place. This is the Moncrieff principle in its broadest features.

But to go a step further, and suppose that in the first case you have not only to lift the weight, but to make it slide in a groove so that it must rub against the sides. All the strains are evidently increased. On the other hand, in the second case, suppose that your rocker is not in the form of a half-moon, but has the end next the weight rounded off in a sharp curve. It must be felt that the first strain is still further decreased. What the ordinary daily acquaintance with nature teaches, so that experience soon makes men feel what is generally right or wrong, mechanicians can calculate with accuracy; and although in the case of the apparatus tried, the weight had not to be lifted directly, but drawn up an inclined plane, so much friction was introduced that it was evident the shock and strain must be terrible.

The first fact remarked by the spectators was that the counterpoise did not bring the gun up to the firing position by its own weight, but that the gunners had to use tackle and much force for the purpose. The second was that the height which the gun rose and fell was small in

proportion to the distance it had to move backwards and forwards, so that a shot coming over the parapet and falling at an angle not less than the incline of the platform would have the gun exposed to it at whatever point in its ascent or descent the piece might be. Then it could not but be observed that there would be no means of loading if the 7-in. were a muzzle-loader, and all our ordnance firing heavy charges are muzzle-loaders. The gun used in the Moncrieff experiments at Shoeburyness fired charges of 23 lbs. of powder. The cartridge of the breech-loader used weighed only 11 lbs. The actual force of recoil was, therefore, much less.

Yet, in spite of these advantages the gun only recoiled 2 ft. 4 in. at the first round, while the counterpoise moved but 1 ft. 3 in. How was this, since they were fastened together by a chain which could hardly have stretched? This chain had not stretched, but the india-rubber buffers had been somewhat crushed up. Clearly the recoil was not sufficient to drag the counterpoise through its grooves, while a lighter counterpoise would mean heavier work to the men who have to haul the gun up into its place after every round. The gun had not moved back as far as had been hoped by those responsible for the apparatus—not far enough to bring it within reach of the men to load. The force that should have been utilized in lifting the counterpoise must have been spent somewhere, but upon what? Partly in crushing the buffers, partly in destructive effect on the apparatus or its bed.

One more round was fired, and the experiment was brought to an abrupt conclusion. The recoil was violent, but short. The gun moved 2 ft. 10 in., and being checked there, transferred to its carriage and platform the force that should have driven itself backwards. The action of recoil, checked unscientifically, was instantly manifest. The gun, with its carriage, was seen to give a furious leap, like a savage beast trying to break its chain. It could not get free, for the chain was strong, but the dash downwards after the spring sent the whole elevating gear to the earth with a ringing fall, while the backward force separated the huge timbers of the bed, and caused the front trucks to jump off their racers and plunge some depth into the wood-work on which the racers were set. A horrible screaming sound was heard, and added to the effect upon the startled listeners; but it was due, not to any unknown damage, but to a motion of the air produced under certain conditions by the firing of heavy breech-loading guns. The piece was of no further use. It could neither be trained right and left nor elevated.

The experiment was made before the Moncrieff Committee, and we will venture to say that they and the other officers present were more impressed with the difficulties conquered by Captain Moncrieff than they had ever been before this negative experiment. The piece used on Friday was a comparatively light one, and its charge less than half the battering charge of a 7-in muzzle-loader, or about a quarter of that fired from the 9-in. gun. There was but one opinion—that such an apparatus was practically impossible for heavy guns.

We should not have noticed it but for the moral impression made upon the officers present. That impression found vent more than once in the words, "Thank heaven there is an end to experiments for the present." Suppose that instead of a failure the thing had been doubtful or even possible. There must have been rivalry set up at once between it and Moncrieff's inventions. The department charged by the British Government with the manufacture of carriages for heavy guns would have been divided against itself, at a moment when all men who have anything to do with the armaments of England should be working together in harmonious strength. The one thing now needful is prompt decision as to the guns, carriages, gunpowder, and small arms to be placed on British works or carried by British infantry. There is no golden age of arms, nor will final and perfect weapons be ever found. Is there to be found a workman of any sort, be he poet, artist, politician, or manufacturer, who has sent forth a single production of which he could say "It is altogether good"? There is a danger that while they are quarrelling and criticising, tinkering and polishing, Englishmen may find themselves suddenly thrust into war with forts half-built and wholly unarmed, commercial harbors undefended, the new infantry arm undecided, Militia untrained. Volunteers armed with muzzle-loading

rifles, and the military forces of the country half helpless for want of organization.

The manufacturing resources of this country are so great that material can be supplied as fast as called for, if only the pattern be decided, and careful supervision insisted upon. There is a great opportunity now for the officials at the War Office to show what stuff they are made of. Considering the present temper of the country there can surely be no difficulty about putting England in a full state of defence. The condition of France at this moment may teach us that days are of as much value in modern wars as months used to be.

SEWAGE PURIFICATON BY A B C.

From "Engineering."

Messrs. Sillar and Wigner's method of purifying sewage has, during the past two years, received an unwonted amount of publicity, and the "A B C process" is by this time tolerably familiar to most people, thanks to the extended trials it has received, and through the assistance of the public press, lay and professional, the latter being represented by "The Engineer," which a few months ago was loud in its praises. On May 27 that journal wrote *apropos* of the Hastings Sewage Works, after describing the effect of the process upon the sewage of that town: "We think this a complete and satisfactory proof of the great power of the A B C mixture to entirely deodorize the sewage. . . . We have no doubt that this simple process is capable of wide adoption throughout this country, as well as on the Continent," etc. Turning, however, to the number for August 12, we read, referring to the same subject, the following: "A mere glance at the evidence before us is more than enough to prove how inefficacious and crude is the A B C process. . . . There is scarcely one of these quack methods which some unfortunate local board or other has not been seduced into experimenting upon with the same results. . . . It is time these delusions were terminated," and so forth. These very contradictory assertions, the former of which almost treads upon the heels of the latter, would be sufficiently striking had they been printed in the columns of a daily paper. But appearing as they do in the pages of a periodical, whose motto is "Consistency in Journalism," the contradiction is worthy of inquiry, and it is quite time to attempt finding which of these statements is the true one, and we may be guided to a result by such evidence, unsatisfactory as it is, as can be obtained. When Messrs. Sillar and Wigner first brought their process into public notice, the novelty and sensational character of their proposition had possibly much to do with its early recognition; we were given to understand that the invention was principally the result of a study of the habits and customs of the Israelites, as set forth in the book of Deuteronomy, and that the inventors had drawn inspiration from that chronicle. An unknown and mysterious mixture, named from the initials of its three chief ingredients, on being cast into the sewage, seized instantly the impurities, and, changing their nature, precipitated them in flakes, until the water containing them was left, you were led to believe, pure and limpid. The solid matter, thus separated, was to be dried and sold at a high price for manure. At a recent Conversazione of Civil Engineers, we remember seeing collected a battery of bottles, containing samples of sewage from all parts of London, from Bayswater to Wapping. The exhibitor of these interesting specimens had, of course, on hand a stock of A B C, with which he constantly purified glasses full of the foul contents of the bottles aforesaid, and it was a sight to see him sipping the residual nectar in proof of his entire belief in the process. How many enthusiasts fell victims to this course of A B C we cannot say; but there is no doubt that their labors advanced the cause they had at heart, and which has been steadily gaining ground until the publication of a recent report of the Rivers' Pollution Prevention Commission, which has set its face dead against the process, whilst the Ha tings catastrophe of the other day at the new

works of the Native Guano Company has helped to accelerate the receding wave of public opinion.

Dr. Odling has placed the patentees in this predicament, that they must be content to remain under the imputation of having deliberately and systematically advocated a useless process, or that they must justify themselves by disproving Dr. Odling's strictures. This gentleman, in his recent evidence before the Rivers' Pollution Commission, stated his conviction that A B C was simply a "juggle." If he had said that the inventors of the process were deceiving themselves, he would have perhaps made a safer statement; for that this is the case there can remain no doubt after the careful official investigations that have recently been made. If we refer to one of Mr. Wigner's statements, which we published over his own name on the 10th July, 1868, it will be found that he relates in detail some careful experiments made with his process at Tottenham; from them we were led to believe that 85 per cent. of the ammonia, and all the phosphoric acid in the sewage, were precipitated, leaving rich and valuable manure containing 2.37 per cent. of ammonia, whilst the effluent water was nearly as pure as that of the Lea, the principal foreign matter being common salt which was discharged from a neighboring factory.

In the same volume of "Engineering," page 129, we published a further statement upon the responsibility of the inventors on the Leicester experiment. Here it was asserted that the effluent water was almost entirely purified, while the manure obtained was worth £4 a ton, containing as it did the most valuable fertilizing constituents, and that, upon the most moderate computation, a return of £160 a day could be relied upon from the sale of the manufactured guano.

It was about this time that the Rivers' Pollution Commission was employed in investigating the real merits of the system as applied at Leicester, and the results at which they arrived were utterly at variance with those hoped for by Messrs. Sillar and Wigner.

The process failed comparatively even in its strong point—that of purifying the water from suspended matter held in suspension. In a former report by the Commissioners it was recommended that the maximum amount of organic impurities held in suspension in sewage water upon its admission into any stream should not exceed 1 part in 100,000, whereas the Leicester water, after it had been submitted to the A B C process of purification, contained more than 3 parts in the same quantity. With regard to the influence of the A B C compound upon the sewage, the results were proved, by the Leamington experiments, to be still less satisfactory. The nitrogeneous organic matter held in solution is among one of the most active agents in river pollution, and we find that this is, under the most favorable circumstances, reduced only about 50 per cent. Passing over various subsequent experiments, conducted by the Commission, we arrive at one carried out by them upon the London sewage with the A B C mixture employed at Leamington. This was, it is true, only a laboratory experiment, but was equally conclusive with the others carried out in practice, and as it was found that in one case, at least, the

Description.	Dissolved Matters.							Suspended Matters.		
	Total solid matters left on evaporation.	Organic carbon.	Organic nitrogen.	Ammonia.	Nitrogen, as nitrites and nitrates.	Total combined nitrogen.	Chlorine.	Mineral.	Organic.	Total.
London sewage collected May 23, 1870	67.3	3.614	1.886	5 418	0	6.348	10.23	10.30	18.00	28.30
Ditto after treatment by A B C process	80.5	2.257	1.878	6 086	0	6 890	10.20	Traces	Traces	Traces

value of the Leamington tests was nullified by the fact that river water was freely admitted into the sewage tanks, the trial referred to is the more satisfactory. The sample of sewage having been mixed in the due proportion with the A B C compound, was allowed to subside, and after two hours the supernatant liquid was taken away and analyzed, an analysis of the sewage before treatment having also been made.

From this analysis it is shown that the total of soluble matter was increased by the addition of the mixture by 13.2 parts, that the organic carbon was reduced 37.5 per cent., that the organic nitrogen underwent no change, that the ammonia was increased, the excess being derived from the alum contained in the mixture, a minute proportion having been precipitated, and that the total combined nitrogen was increased by the action of the ammonia added. The effluent water, therefore, possessed a greater value as manure than the raw sewage.

On the other hand the precipitation was very satisfactory.

The utmost credit, then, that can be given to Messrs. Sillar and Wigner's process appears from these results to be that it may act as a tolerably complete precipitator, a result, however, which can be brought about by less costly means than they employ.

It is very difficult to understand how the inventors could have advanced such statements as those to which we have already referred, and which we first published two years since. It was, as we have said, asserted that 85 per cent. of the ammonia and all the phosphoric acid were precipitated, and upon this statement was based the commercial value of the process. That this statement is, to say the least, sanguine, we have now ample evidence to prove, as well also as the other confident assertion upon the market value of the dried residue, to be sold under the name of native guano, which we are told is worth £3 10s. per ton in the neighborhood of Leamington. The Commissioners' report upon this point is very complete, and until disproved we may assume it to be reliable. We give the analysis of samples taken at Leamington to be as follows :

Mineral matter	54.772
Organic and other volatile matters	45.228
Carbon	24.994
Phosphoric acid	.496
Total nitrogen	1.943
Ammonia	.185
Total nitrogen	2.36

Two very different estimates may be formed of the value of this residue, a theoretical and a practical estimate. In the former case, the market value of the different fertilizing elements being given, the theoretical worth of the manure is obtained. Thus with ammonia at £59 per ton, and superphosphate of lime at £32, the "native guano" should realize £1 13s. 0¾d. per ton. But experience has shown that a totally different result is arrived at in practice. The Leicester sewage, treated with lime, gave a theoretical value of from 15s. to 17s. per ton, yet 1s. per ton only was its selling price. We do not necessarily infer, nor, we believe, would the Rivers' Pollution Commissioners assert, that the A B C products must suffer a proportionate depreciation ; but there can be little doubt that a wide difference exists between the price based upon chemical composition and the actual amount the manure will realize. Assuming, however, for a moment, that £1 13s. 0¾d. is not an excessive figure, it then remains to be seen at what cost the native guano is produced. And here we take, again, the results obtained by the Commissioners, and published by them in their report. Taking the work of one day at Leamington, we find that 2,523,520 lbs. of sewage were treated by the "A B C" in 8½ hours ; therefrom resulted 1,052 lbs. of mud retained in the tanks, or ⅝ths of the total matters held in suspension by the sewage. To precipitate this quantity, 1,834 lbs. of "A B C" were added, of which 1,201 lbs. were arrested with the sewage deposit, the remainder having been swept away, for the most part in solution, with the effluent water. There remained, therefore, 2,253 lbs. of solid matter. To this weight 7.46 per cent. should be added to bring the manure to its exact condition as an article of commerce, that proportion of water being contained in it. We thus get a total of 2,435 lbs., the theoretical value of which, calculated upon the basis before given, is £1 14s. 9d.

Now the actual value of the material used in precipitating the 1,052 lbs. of sewage was £1 18s. 5d., a portion of which

was not lost, being retained in the 1,201 lbs. of A B C recovered. The fertilizing value of this quantity is theoretically 11s. 7d., leaving the assumed value of sewage obtained £1 3s. 2d. But to gain this result we have seen that a sum considerably larger was necessarily expended, and to this of course have to be added the expenses of labor, the deterioration of plant, the cost of working the same, and the interest on capital employed. And, of course, when we bring the market value of the manure to practical figures, the loss will be vastly increased. With regard to this actual value it is somewhat difficult to arrive at absolute conclusions. Compared with Peruvian guano, or superphosphate manure, the "native guano" stands thus:

Ingredients per 100 parts.	A B C Manure.	Superphosphate.	Peruvian guano.
Combined nitrogen	1.695	.40	14
Equal to ammonia	2.050	.50	17
Phosphoric acid, equal soluble phosphate of lime	3.26	26.00	7
Neutral phosphate of lime	..	10.00	22
Soda salts	..	..	8
Potash	..	..	

The small proportion of fertilizing material which, according to these analyses, the A B C manure possesses, would necessitate the application upon land, of a proportionately larger quantity than either of the other two, these proportions in fact being as 160 to 55 of the one and 20 of the other. Independently of the cost of transport and the delay, and expense, and inconvenience of spreading such an excess of fertilizing material over the soil, it would appear from evidence, and upon the test of experience, that the important elements of manure are greatly reduced when mixed with a large quantity of useless matter, and it is this useless matter that agriculturists are called upon to purchase at a considerable price. The only inference to be gathered, then, from the investigations to which we have referred is, that, by a costly and as yet an imperfect process, an inferior and dirt-encumbered manure is produced, the value of which is less than that of the precipitant employed. And, as a natural consequence, the effluent water which is passed off afterthe precipitation, is heavily charged, not only with impurities injurious to any river purification, but containing also the most active elements of fertilization, as well as valuable component parts of the compound employed for the separation of the "native guano." These results, falling short of the first sanguine anticipations of the advocates of this system, have probably led to the recent suggestion that, by a judicious combination of dry manure and sewage irrigation, the golden mean could be struck, and the very perfection of sewage utilization attained. But so long as we have the facts before us which have been so clearly put forward in the report to which we have referred, there seems to be no way of avoiding this difficulty, that an extreme cost is required to separate the solid from the liquid portion, and until some sufficiently cheap method be devised, it would be simply impossible, with any regard to economy, to go through so much to gain so little, to precipitate at such a sacrifice a small proportion of the whole. We do not say that there is no practical merit in Messrs. Sillar and Wigner's system, but the arguments advanced against it in its present form of working are so overwhelming, that the advocates of the process will either have to disprove them conclusively in every detail, or will be forced upon the admission that they have yet to learn the real A B C of sewage ventilation.

TRIANGULAR DRAWING-BOARD.—Mr. Geo. Fawcus, of North Shields, England, has contrived an equilateral triangular drawing-board for isometrical drawing. An ordinary T square applied on the edges of an equilateral triangle draws tangents that meet each other at angles of 120°, and other lines drawn parallel to these radiating ones form with them angles of 60° and 120°, which are the exact angles of the apparent squares of isometrical cubes. The inventor believes that the use of this new drawing-board will make the teaching of isometrical drawing both simple and easy. The practice of isometrical drawing is strongly urged in the science and art drawing classes.—*Nature.*

BREECH-LOADERS FOR ENGLAND.

From "The Mechanics' Magazine."

Now that the bloodless battle of the breech-loaders at Wimbledon is over, the attention of the country is turned to the selection of a weapon for England's army which shall in turn replace the Snider, and during the recess a good opportunity is afforded for reviewing the results attained by the last Wimbledon breech-loading competition. Before another session shall have been brought to a close it is quite probable that the Select Committee and the Government will have decided upon the weapon of the future. Of the many rifles which have been introduced to the public at Wimbledon, those invented by Messrs. Henry, Soper, Westley-Richards, and Martini, the result of the last three years' competition has proved that these men only are in the front rank as producers of a breech-loader, and on the rifles of these inventors we now propose to make some few remarks. In the first place, it may be interesting for our readers to fully understand the nature of the breech and lock mechanisms of these four rifles, and for the purpose we give an accurate description of each rifle, which we hope will be comprehensible to non-scientific as well as scientific readers. It will be seen that in the construction of the breech and block mechanisms there are fewest pieces in the Soper and Westley-Richards rifles, while in the Henry rifle there are more than double the number. Moreover, the Soper rifle has a side lever, which can be pressed immediately the shot is fired, while in the case of the other 3 rifles the hand has to be carried under the rifle for the purpose of pressing forward the lever to open the breech each time the shot is ejected. To the Henry rifle is attached a cock similar to the Enfield, which necessitates the use of both hands in rapid firing. This would be a great disadvantage to a soldier in warfare, for it is evident that in whatever position he may be he must have one hand with which to hold the rifle.

The Henry rifle, pure and simple, contains in the lock and breech action complete 46 pieces—23 pins or screws, 6 springs (2 of which are spiral), and 17 other pieces. The stock is in two parts. The principle of the rifle is that the breech-block is operated upon by a lever pivoted at the bottom of the breech, and moves freely up and down in a slot, and vertically through the breech shoe. The old pattern back-action lock is retained in this rifle, which necessitates a separate action in cocking, thereby preventing that rapid firing which has been attained by other rifles, excepting when the rifle is secured by straps and other contrivances which admit of the firer using both hands in loading and firing, as in the case of Messrs. Farquharson at the late Wimbledon competition.

The distinguishing feature in the Martini is the unusual length of the breech shoe, which is made to admit of what is termed a drop-action breech-block pivoted near in line with the top of the cartridge, so that when the block is lowered the whole case can be ejected and the new cartridge inserted in an oblique direction. The block contains within itself the plunger or striker, which is operated upon by a spiral spring. The breech-block is worked by means of a lever pivoted or mounted on a trigger guard held in its place by a spring. The lowering of this lever depresses the breech-block, and acts upon the extractor. When the lever is returned to its place, it forms a bow like a second guard, which is found very much in the way when the rifle is required to be used with a bayonet. The breech and lock action and fixing for the same consists of 27 pieces, four of which are springs, the mainspring itself being the ordinary spiral spring coiled round the striker, which readily accounts for the great number of misfires which occur with this rifle. The stock is in two pieces, and is pronounced by the Select Committee to be very weak.

The third rifle now prominently before the public is the Soper rifle. The chief feature of the Soper direct-action rifle is that the lever is mounted on the right side of the rifle in the place of the ordinary cock, and so conveniently arranged that it can be immediately depressed on the firing of the rifle. The depression of this lever forces back the striker, raises the breech, cocks the gun, and ejects the cartridge. The breech-block is pivoted

on the right side similar to the Snider. The lock action is identical with the Enfield in principle, and so arranged that the cock strikes a blow in the centre of the rifle in line with the axis of the bore. The cock is connected by a swivel to the ordinary mainspring taken from the Enfield. This arrangement insures a certain blow being struck on the cap, and at once accounts for the fact that no misfires occurred at the Wimbledon meeting when the new Government cartridge was used. The lock and breech action consists of 17 pieces—2 springs, neither of which are spiral, 3 screws, and 1 pin. The stock is in one piece and exceedingly strong ; the lock has the ordinary half-cock, at which position it can be loaded. It is also furnished with the ordinary snap cap, which is used with the Enfield rifle, an advantage not possessed by the other rifles, but which is of the greatest importance in a military gun.

The Westley-Richards rifle is similar in construction to the Martini, with the exception of the spiral spring, which in the Westley-Richards is disposed of, the V-pattern spring being used instead. In some of the rifles the stock is in one piece ; one or two good scores were made by this arm at the late Wimbledon meeting. From its peculiar construction it is not well adapted for the present Government cartridge, as the striker has no other support but one mainspring, and is therefore unable to be driven backward, and the hole in the breech-block filled with the cap from the cartridge, which would at once block the rifle and prevents its action. A special cartridge is therefore obliged to be used which is not liable to this particular mishap.

It was noticeable at Wimbledon this year that many of the best Wimbledon shots, including Sir Charles Shakerly, Mr. Edward Ross, and Mr. Dunlop fired the Martini rifle during the first week, and most signally failed. It was in the second week of the trial that the competition got exceedingly warm, and when the Henry and Soper rifles in turn gained popularity. Such men as Sir Charles Shakerly and Mr. Dunlop, who had failed with the Martini gun the first week, now went in and made winning scores with the Soper rifle. It is needless for us to recapitulate the events which marked the proceedings of the second week's competition at Wimbledon. It has already been stated that the Soper rifle made some of its best scores in the presence of Lord Elcho and members of the Government, and the result of the whole fortnight's competition has shown that out of the ten best scores made for the Bass prizes eight of them were made by the Soper rifle, while at the 500 yards more than half the nine scores were made by this rifle. These scores have been examined by Captain St. John Mildmay, and published in the "Volunteer Gazette" of August 6, 1870. We now have the reports of the Select Committee on the Government rifle before us, and, judging from their unsatisfactory nature, we have little doubt but that the Government will be induced to reconsider the question of the future military gun before they proceed with their manufacture. The simplicity of action and the strength of the arm must be a great desideratum in a military breech-loader; and after all that has been written there are many other questions to be considered besides rapidity of fire. The general construction of the arm as a military gun is of vital importance, and it would be most unwise to place such an intricate piece of mechanism as the Martini in its present condition in the hands of a common soldier. What is now required is the appointment of a committee of mechanics, who shall examine and report to the Select Committee on the principles of the four rifles which have proved themselves in competition at Wimbledon with the rifles of the world to be worthy of the notice of the Government. There should be no favor shown, but an impartial report and a fair trial for all.

Two competing submarine cable companies, the China Submarine and the Great Northern and China Extension, have agreed to work together and divide receipts. The lines from Singapore to Japan are to be finished before the end of 1872. The combination is for 30 years.

The new elevator of the Milwaukee and St. Paul Railway Company, at La Crosse, has capacity to store 125,000 bushels of grain, and to transfer from barge to car 5,000 bushels per hour. It has a 100-horse power engine.

ON SOLUBLE GLASS.

By PROF. CHARLES A. JOY.

From "The Journal of Applied Chemistry."

The value of this article for many purposes in the arts, and the want of a popular knowledge of its properties and uses, induces us to compile from the best sources the following paper on the subject, in the preparation of which we shall avail ourselves more particularly of the reports of Professor Wagner on chemical technology, and of the learned researches of Fuchs and Kuhlman,

Soluble glass, called also water glass, liquid quartz, liquid silex, silicate of soda or potash, was accidentally discovered by the late Professor Fuchs, of Munich, in the year 1818, in the course of some investigations he was making for the preparation of pure silica. He became more familiar with its properties in 1820 and learned how to prepare it by the solution of silica in caustic potash. Afterward he studied the subject thoroughly, and became acquainted with all its properties and its uses. In the year 1823, as the theatre in Munich which had been destroyed by fire, entailing great loss of life and property, was rebuilding, the Government requested a scientific commission to search for an agent that would render the woodwork and stage appointments incombustible. Professor Fuchs, in association with Dr. Pettenkofer, at once instituted numerous experiments upon soluble glass as the best agent for this purpose, and the conclusions at which they arrived have been fully confirmed by the subsequent studies and experience of other men. In 1826 soluble glass was manufactured in Augsburg on a large scale, and sold at the rate of 25 florins the 110 pounds. From this time forward a knowledge of the new compound became disseminated, and new uses were constantly suggested for it.

According to Professor Fuchs there are four kinds of soluble glass:

1. Potash glass.
2. Soda glass.
3. Potash and soda glass (combined).
4. Glazing glass.

Potash soluble glass is prepared by fusing together:

45 lbs. of quartz.
30 lbs. of potash.
3 lbs. of charcoal in powder, and digesting the fused and pulverized mass in water.

Soda soluble is composed of:

45 lbs. quartz,
23 lbs. calcined soda.
3 lbs. charcoal.

Or, according to Buchner, more economically of:

100 lbs. quartz,
60 lbs. calcined glauber salt,
15 to 20 lbs. coal.

There are several ways of making the third variety of combined soda and potash soluble glass. By fusing seignette salt (tartrate of potash and soda) with quartz; by employing equal equivalents of nitre or Chili saltpetre and quartz; fusing cream of tartar, Chili nitre and quartz; or by melting at once:

100 lbs. quartz,
28 lbs. purified potash,
22 lbs. calcined soda,
6 lbs. charcoal powder.

For technical application it is possible to mix three volumes of a concentrated potash glass solution and two volumes of a soda glass solution.

The fourth variety, called glazing or fixing glass, is made by mixing perfectly saturated potash glass with soda glass, and is used for producing fast colors in stereochromy and fresco painting.

There is also a wet way for the manufacture of soluble glass, which consists in dissolving flint stones in concentrated soda lye in iron boilers under 7 or 8 atmospheres of pressure, and for this purpose infusorial silica or tripoli is also especially adapted. The tripoli is first calcined to destroy all organic matter and then introduced into boiling soda lye of 1.5 specific gravity or potash lye of 1.135, and afterward clarified by a little water lime and evaporated to the required consistency. As soluble glass readily absorbs carbonic acid, it must be kept in closely stopped packages. The strength of the solution is estimated in degrees founded upon the package of dry powder dissolved in the water; 33 deg. means 33 parts dry glass and 67 parts water; 40 deg.=60 parts of water and 40 parts of soluble glass. In applying this solution to wood-work, roofs,

fabrics, porous stones, etc., it is necessary to begin with a weak solution and to wait until it is thoroughly dry before putting on a second coat. The second application can be considerably more concentrated than the first. It will not adhere to freshly painted surfaces, but when the oil is thoroughly dry and changed in the sunlight, the water glass can be used with impunity. Care must be observed to wash out the brush thoroughly after use, to prevent its hardening to stone. Soluble glass protects wood from the influence of fire, water, and the atmosphere. The surface of wood is covered with glass, and not only will not take fire, but is less liable to decay. Some varieties of wood are apt to be discolored by the solution; oak and beech are the least affected. As the soluble glass when applied to wood serves a purpose analogous to a varnished surface, it is necessary to avoid a too concentrated liquid, as otherwise it is liable to scale off. One pound of 33 deg. solution, diluted with five pounds of water, is found to cover wood very well. Wood, paper, linen and straw, when covered with several coats of soluble glass, are no longer inflammable, but simply char when exposed to fire. A coaitng of glass also prevents the decay and rotting of wood, and keeps out worms. Beer barrels, butter firkins, and milk tubs can be easily kept clean when painted with soluble glass, and the same is true of vessels designed to hold sugars, syrups, wines, petroleum, etc. The most important use of soluble glass is its application to surfaces of stone and mortar. For this purpose it is necessary to impregnate the surface with a solution composed of one part 33 deg. and 3 parts rain water. For this purpose a powerful pump or syringe, with a spout like a watering-pot, is used for injecting the liquid, in the form of syrup, into the pores of the stone or mortar. The surfaces thus prepared are in condition to receive the further coating of liquid quartz.

Mortar and porous limestones react upon the soluble glass, producing carbonate of lime, hydrate of lime, and, ultimately, silicate of lime, which thus presents an impervious vitreous surface, capable of resisting the action of moisture and the atmosphere, and is in a proper state for fresco painting in mineral colors. Organic colors are apt to be destroyed by the alkali of the soluble glass, and hence, for fresco painting, mineral paints are alone available. A second coating of paint, rubbed up with soluble glass, is usually sufficient for all practical purposes, and a wall thus treated can be washed with soap and water, and kept thoroughly clean. A plain, white color is obtained by mixing chalk with soluble glass. Zinc white and silicate of soda set so rapidly that it is necessary to add $\frac{1}{4}$ to$\frac{1}{2}$ its weight of precipitated sulphate of baryta before applying the color. Baryta white and soluble glass also afford a good, fast color. Fluor spar with pulverized glass and soluble glass also gives an exceedingly solid mass. The pigments that have been found by experience to serve the best purpose are chromate of zinc, sulphide of cadmium, blue and green ultramarine, schweinfurth green, oxide of cinnabar, etc. Prussian blue and colors prepared from it and chromate of lead, chromium, will not answer, as they are destroyed by the alkali, the same as organic colors. It is well known that the fresco painting in the Capitol at Washington, in the new museums in Berlin and Munich, are done with water glass, and the success in their use is complete.

Soluble glass, with or without colors, adheres closely to such metals as iron, zinc and brass, and protects them from the influences of the air and water. It has been found that when stoves are painted with a mixture of soluble glass and black oxide of manganese, a species of flux is produced by the heat, which does not scale off, but thoroughly protects the iron from any corroding action Plate glass, when coated with the soluble silicate, becomes opaque, and when baryta is mixed with the liquid quartz it assumes a fine, white appearance. If the glass be heated it becomes enamelled, like porcelain, and fixed colors, such as ultramarine and oxide of chromium, open up an extensive application for soluble glass for transparencies, church windows, etc. The manufacture of artificial building stone by means of soluble glass has been conducted in Germany and England on an extensive scale. In Vienna, barracks of an enormous size have been constructed of such artificial stone, and the tower of the Cathedral in that city was put into thorough repair in the only way that was possible, considering the great height of the tower and the extent to which it had fallen into decay.

When ground chalk or marble is stirred into a paste with soluble glass, the mass

becomes so hard that it can be employed for building purposes, or for the restoration of decayed stone structures.

Marble and dolomite immersed in a solution of soluble glass, and the operation repeated a number of times, take up an appreciable quantity of silica and become so hard that they are capable of taking a fine polish. Attempts to employ such stones for lithography have been made, but not altogether with success. Artificial stone can be prepared as follows:

Well washed and gently heated sand is stirred into a warm solution of soluble glass until a proper consistence has been reached for pouring it into a mould. After it has set it is removed from the frame, which ought to have been previously oiled, and is left to dry in an airy place. To avoid too great a consumption of water glass, a stone or brick can be put in the centre of the mould. It is also possible to stir in pebbles and to use earthy colors in imitation of marble and conglomerate. Such artificial material becomes very hard, and is adapted to pavements, hearths, and building purposes.

Soluble glass can be used in the manufacture of paper-hangings, for printing on paper and woven fabrics, for attaching gold and silver powder to any kind of object.

Hydraulic lime can be prepared by mixing in fine powder 10 to 12 parts by weight of dry soluble glass and 100 parts of lime —this affords a ready way of preparing a hydraulic cement from ordinary lime, which is always available.

One of the earliest and best known uses of soluble glass is as a cement for glass, porcelain and metals. It is put up in small packages for this purpose, and sold on the corners of streets under various names. Pieces of glass or porcelain cemented in this way will break more readily in places which were whole than where they were repaired. The solution ought to be quite concentrated when employed for this purpose. The fragments to be repaired must be heated to the boiling point of water, and both surfaces be then moistened with the cement and pressed closely together and held in position by a strong cord, and left to dry in a warm place. By mixing sulphate of magnesia or calcined magnesia and soluble glass, a cement can be formed that can be cast into moulds, and very generally be substituted for meerschaum.

Soluble glass has been used in restoring several European churches, also the Houses of Parliament in London.

Wood and timber and other porous substances, after being boiled for several hours in soluble glass, then exposed in tanks containing lime water or chloride of calcium and magnesia, and left to dry, become highly vitrified and incombustible. Railroad ties, ship's timber, house and bridge beams, have been treated in this manner with entire success.

The silicate is also used for penetrating fire brick and clay, and for cementing the walls of furnaces.

When stirred up with chloride of calcium and used for luting down the covers of crucibles, it answers an excellent purpose.

Repeated attempts have been made to use soluble glass as a substitute for soap, as well as for adulterating soap; but the reports of a commission in Prussia, where trial was made at the State's prison of Spandau, was unfavorable. The detergent properties of the silicate are not very great, and it cannot be recommended, excepting in a few cases where grease is to be removed from the fleece of wool, or some similar cleansing is to be performed.

As a species of lubricator, and to preserve the elasticity of leather, soluble glass has a ready application.

We have thus compiled from various sources, and have put together from our own knowledge and experience, some of the leading facts in reference to soluble glass. It is somewhat remarkable that an article of so much value in manufactures, and capable of such extensive use in the arts, should be so little known and so rarely applied. And it is for this reason that we have devoted so much space to its consideration.

STREET CAR "MAN CATCHER."—Mr. U. B. Vidal, of Philadelphia, proposes to provide the street-cars with strong skirts or nets, supported on frames to extend from the flooring down to or near the ground. The object of the improvement is to save persons who fall from being run over by the car. The frame which supports the net is to be elastic, vertically, so as to yield when any portion touches the ground.

PRINCIPLES OF TRACTIVE POWER IN LOCOMOTIVES.

By P. BARNES, Jr.

From "The Railroad Gazette."

The power of any locomotive is limited by the *friction*, or resistance to slipping or sliding between the tread of the driving wheel and the rail. The word "adhesion" is sometimes used in this connection, but it can be applied with correctness only to a resistance like that which is offered to the shearing of a body, as a bar of iron, in which the particles of the metal are forced to move or slide upon themselves while the shearing is taking place. Hence the ability of an engine to move a load will depend upon *the weight resting upon its driving wheels and the condition of the surface of the rail*, because the most careful special experiments and extended observation in practice show that, in common with metals so nearly similar in character as rails and tires, whether of iron or steel, the friction is almost exactly proportional to the perpendicular pressure between the surfaces, or, in the case of the locomotive, to the pressure upon the rail. It is by this friction that the wheel is prevented from revolving freely when pressure is brought upon the piston, and this friction is always greatest, and the engine can draw the heaviest loads, when the rail is either perfectly dry or perfectly wet, so that the surface of the tire may come into close contact with the surface of the rail without the intervention of any slippery film of moisture.

The general law, deduced from the most exact experiments, is that the force required to move one body when sliding upon another corresponds very nearly to the perpendicular pressure between them multiplied by the *coefficient of friction*. This coefficient is simply the relation or proportion which the pressure required to move a body upon any surface bears to the weight of the body itself, and for general purposes may be stated to be from 1-20 to 1-10 between metals when properly oiled. If the surfaces are not properly smoothed, or if the pressure between them is so great as to produce grinding or abrasion, then this law will not hold good, but the coefficient will increase rapidly to a point determined by the special condition of the case. It is also evident that this condition or proportion will diminish when the surface sustaining the weight of the rail, in the case of the locomotive, becomes more slippery than usual, as when snow or ice accumulate on the track, or sometimes during a slight rain, and hence, as is well known, the tractive force of any engine may be very greatly reduced at such a time.

Since, then, the power of a locomotive depends so entirely, other things being equal, upon the weight carried upon its driving wheels, it might seem necessary merely to increase the total weight of the engine by loading it with pig-iron in order to increase its tractive powers; but further consideration will show that this is not true. To illustrate the actual state of the case, suppose a locomotive to be firmly attached to a solid rock which cannot be moved. If steam be then admitted to the cylinders, a pressure will be brought upon the driving wheels tending to make them revolve, and in this supposed case they can only slip upon the rail. This slipping will always take place when the pressure upon the piston due to the steam within the cylinder is greater than the product of the weight of the engine multiplied by the coefficient of friction, since, as has already been shown, there is no other means than this of holdng the wheels to the rail. Slipping will not occur in this case if the pressure upon the piston is less than the product of these two factors. If the weight of the engine be not great enough to prevent slipping for any given size of cylinder or pressure of steam, then an increase of weight may usefully be made, so that this product may be increased, by which, as has been shown, the tractive power of the engine is measured or limited.

It will be seen, then, that with any given size of cylinder and standard pressure of steam a certain weight must be given to the locomotive, so that, under ordinary circumstances of weather, etc., no slipping of the wheels may occur, and also that no useful result can be obtained by increasing this weight beyond this certain amount; for the pressure upon the pistons cannot be increased beyond this assumed

limit, and hence no additional load can be drawn, even though no slipping should take place.

The objection urged against the use of six-coupled engines, that they have a long rigid wheel base, is an important one, and it is receiving serious attention in England, where these engines are vastly more common than in this country. Few builders, however, would put three pairs of driving wheels under any engine without making the boiler and other parts longer or heavier, so as to furnish a weight to be borne upon each pair of wheels equal, or nearly so, to that borne by each pair of wheels of an ordinary four-coupled engine, so that the larger engine may be efficient just in proportion to its size.

The grand objection to any increase of the weight of our engines, as now constructed, is that it is too destructive to the track to load each pair of wheels even as heavily as is ordinary now. The blows dealt by passing wheels upon the rail joints, and the bending or breaking strain brought at any instant upon the joint in the rail where a wheel presses, depend upon the weight which the wheel carries as well as the speed at which it moves, and hence to diminish our track repairs, that which is nearly or quite the most greedy of all maintenance accounts, the load borne per wheel in our locomotives must be lessened at least one-half, so that it may more nearly agree with the load borne per wheel in the cars. How this can be done without increasing the rigid wheel base, while the present boiler and cylinder capacity are retained, is one of the most trying problems of the present day among locomotive builders, and certainly the most promising commencement of its solution is the introduction of the Fairlie engine, notwithstanding the numerous complications with which it is still beset.

HISTORIC METROLOGY.

From "Engineering."

All systems of weights and measures of the present day are but the *debris* of what was once an elaborate and highly-finished system, and can all be traced back to times preceding any known work of man, except it be the division of the zodiac and classification of the stars, to one original system, as distinctly as languages can all be traced back to one primitive language. Exceptions of course occur. It is not, therefore, surprising to find that weights and measures, instead of being based on arbitrary and whimsical standards, as the world is taught, such as the length of some man's arm or foot, are based on standards taken from nature.

Of these standards the circumference and surface of the earth have been adopted for land and itinerary measures. For weights and other measures the most important units are the ordinary sized barleycorn, the large barleycorn, and the corresponding *abercorn*, or ordinary sized water grain, known in England as the troy grain, in Egypt as the habbah and the large abercorn.

The circumference of the earth, for times before the creation of the world, according to orthodox teaching, was fixed at 25,000 English statute miles, and this fact has ever since been more or less known (John Fernel, it would seem, was one of the inheritors of the knowledge), and the surface was represented by a parallelogram of two squares, each of 10,000 statute miles in length.* This parallelogram was divided, both lengthwise and broadwise, similarly to the circumference, into 360 deg., and each degree again into 60 parts or miles.

The mile thus obtained lengthwise (4,888$\frac{8}{9}$ English feet) is the old Roman mile, of which so much has been written, and so many conjectures hazarded; and the old Roman foot was the 1–5000th part of this mile (11.7333 English inches), differing only 1–100th of an inch from the Roman foot of the present day. One-tenth of 4,888$\frac{8}{9}$ English feet is the exact vertical height of the Great Pyramid.

Of the units specified, the abercorn, or ordinary sized water grain, is a weight equal to the weight of a mass of water of the bulk of the ordinary sized barleycorn, and the relative weights of the several units are in the ratio of the numbers 8, 9,

* These dimensions are based on the supposition that the ratio of the diameter to the circumference is as 22 to 160.

$10\frac{2}{3}$, 12, correponding to the fourth, fifth, and major tone of the musical scale.*

The weight of the barleycorn is therefore three-quarters the weight of the abercorn, and 3 abercorns are equal in weight to 4 barleycorns. Hence the word "troy," which, as Lord Swinton surmised, is a corrupt pronunciation of the French word *trois*.

The size of the barleycorn and of every grain—and in this statement the key to the whole mystery of weights and measures is contained—is the length of the side of a cube of water of the weight of the grain; and from information afforded by the pyramids of Gyzeh, the bulk of the ordinary sized barleycorn was fixed such that $333\frac{1}{3}$ barleycorns were contained in $\left(\frac{6944\frac{4}{9}}{6912}\right)^3$ English inch, and the formula $12^5 \times 10^3 \times 44$ expressed the numbers of barleycorns equal to the circumference of the earth.

From standard measures still existing it would appear that the size of the barleycorn was subsequently modified, and 1,000 barleycorns were made equal in bulk to three cubic English inches, and the length of the barleycorn consequently reduced to $\sqrt[3]{\frac{3}{10}}$ English inch. In the first instance, the weight of water was determined at 248.12 troy grains per cubic English inch, and in the other to 250 troy grains.

Another modification took place, for the sake of harmony and relationship, by which the length of the barleycorn was again reduced to $\frac{12^2}{10^2}$ English inch, and for the same reason the relative lengths of the barleycorn and water grain measures were generally assumed to be as 10 is to 11, instead of as the $\sqrt{3}$ is to $\sqrt[3]{4}$.

These modifications, which doubtless took place at intervals far apart, seen through the long course of ages that have transpired since they were adopted, appear to merge all into one system, and tend much to complicate the subject. By these changes alone three different standards are obtained for every measure.

By the last specified system the size of the ordinary barleycorn was fixed at .144 English inch; according to Kelly this is the exact length of the Chinese *hoon;* the size of the large barleycorn at .15 English inch; the size of the water grain at .1584 English inch; and the size of the large water grain at .165 English inch.

It is worthy of remark that, from experiments that have been made, these results agree with the absolute thickness or diameter of barleycorns of the present day. Thirty-three of the largest barleycorns that could be procured, placed side by side, measured on an average .154 English inch each. The cubit consisted of 144 grains, consequently the barleycorn cubit was 20.736 English inches long, exactly $\frac{1}{2}$ the length of the double cubit measure found embedded in the walls of the palace of Karnac, and now deposited in the British Museum, where it may be seen—wonderful to relate—as round and fresh as it was the day it was made, although probably some 3,000 or 4,000 years have since elapsed; the large barleycorn cubit was 21.6 English inches, still preserved at Florence, Mentz, and many other places; the water grain cubit was 22.8096 English inches long, and the large water grain cubit was 23.76 English inches long.

It would be quite impossible, even if it were desirable, to write an essay on weights and measures in form of a letter, and therefore the few observations that follow will be confined to connecting the previous statements with existing systems of weights and measures.

For reasons not clearly discernible, at some early period or other new systems of weights and measures were introduced, the measures of which were just $\frac{5}{6}$th the length of the measures previously existing, and the weights were to the old weights in the ratio of 5^3 to 6^3.

Now $\frac{5}{6}$th the large barleycorn measures formed the *Olympic* measures, of which the English foot and yard, the Bombay covid, the Bengal cubit, the Madras covid, the Guinea jactan, the Malay hastah, are among the remnants. Five-sixths the large water grain measures formed what Hero* denominates the *Philœtarian* measures. Of these the English furlong, mile, acre, are modern examples, and the English ton weight is the weight of the cubed

* Another important unit it is well not to pass unnoticed was the grain, equal in weight to 1 1-9th troy grain

* Hero was a mathematician of celebrity, and wrote a work concerning metrology, fragments of which have descended to modern days, he lived, it is supposed, in the third century B. C.

Philœtarian yard of pure water. The Philœtarian yard (39.6 English inches) is also the 1-10,000,000 of the quadrant of a meridian of 25,000 English statute miles, and is also the length of a pendulum vibrating astronomical seconds ($\frac{365.24}{360}$ ordinary second), on the supposition that the force of gravity is 384 English inches; (the number 384, it is to be remembered, is, as Plato says, the first of unities); and that the ratio of the diameter to the circumference is as 32 is to 100—a ratio that wonderfully simplifies all calculations connected with the sphere, and which there is reason to believe was adopted by ancient inhabitants of the world.

It will be observed that the Philœtarian and Olympic systems are corresponding measures; the cubed Philœtarian foot of grain, the Hebrew epha, being equal in weight to the cubed Olympic foot of water, the Hebrew bath.

Five-sixths the ordinary barleycorn, and $\frac{5}{6}$ths the ordinary water grain measures, are measures of equal repute to those that have been named, and constitute some of the principal measures of the present day, but must be left without further notice. It may, however, be observed that $\frac{5}{6}$ths the ordinary barleycorn cubit is $\frac{1}{2}$ the length of the side of a cube of water of 2,000 old Roman litras (5,184 troy grains); $\frac{5}{6}$ths the large barleycorn cubit is $\frac{1}{2}$ the length of the side of a cube of water of 2,000 old pounds of 5,832 troy grains, still preserved at Warsaw and Alexandria, and is the pound that was introduced into France by Charlemagne. Five-sixths the ordinary water grain cubit is $\frac{1}{2}$ the length of the side of a cube of water of 2 000 Egyptian ratels (6,912 troy grains), and $\frac{5}{6}$ths the large water grain cubit is $\frac{1}{2}$ the length of a cube of water of 2,000 lbs. of 7,776 troy grains, the proper weight, it is believed, of the French pound—*poid de marc*—preserved unimpaired at Oran and Tunis. Twice 7,776 troy grains is the weight of a cube of water $\frac{1}{10}$th the length of the Philœtarian yard, and the cubed Philœtarian yard is, as has been previously observed, the weight of the English ton. In the above examples the weight of water has been assumed 250 troy grains per cubic English inch.

To dispel any lingering doubts as to existing weights and measures having proceeded from one ancient universal system, a few more facts will be mentioned.

In Ceylon, not only the long measures, but, what is a strange coincidence, the land measures are the same as in England. In India, north, south, east and west, the English cubit is a native measure, and is also found among the Chinese and Malay measures. The Madras land measure, the Cawney, the Malay land measure, the Orlong, the Coptic Feddan, are all one and the same measure, and consist of 4,000 square ordinary water grain yards. The Indian biggah is exactly $\frac{1}{4}$th this measure. The Swedish tunneland and the saccata of Florence are identical measures. The toch of Vienna and the Lisbon acre each consist of 4,000 square large water grain yards, and the examples could be greatly multiplied. The English acre consists of 4,000 square Philœtarian yards, as has been before alluded to. Unless weights and measures have originated from one source, how are these facts to be accounted for? How is it that different nations of different races, scattered over the face of the earth, possess the same standard measures? It cannot be ascribed to chance, and to suppose that they have been introduced with colonization is as reasonable as to believe that the English and other European words to be found in Sanscrit dictionaries owe their position there to the same agency.

I had intended to have entered more fully into the construction of English weights and measures, once held sacred and preserved among holy things, now debased among the lowly; but I fear this letter has already extended to too great a length, and I will therefore only add one further fact to show the antiquity of English measures and the insubordinate nature of weights and measures generally.

By the statutes of the realm, from the earliest Norman days, the weight of the quarter was declared to be 512 troy lbs. This measure is an old Hindoo measure found specified in Sanscrit works, but there is no standard measure or other evidence existing to show that it was ever adopted in England.

The English quarter of water is, and seemingly always has been, equal in weight to $777\frac{7}{9}$ troy pounds. The quarter of grain is a less definable measure, and there is no knowing what it is. Four

quarters of water (311⅔ troy pounds) is exactly the weight of a cube of water whose side is the length of the double barleycorn cubit of 144 barleycorns $\sqrt[3]{\frac{3}{10}}$ English inches long, weight of water being 250 troy grains per cubic English inch, and in capacity is equal to the contents of the stone chest of the Great Pyramid. Should any of the foregoing statements be questioned I shall be ready to bring up reasons to their support.

THE METALS AND THEIR ORES.

By EDWARD GLEDHILL.

From "The Mining Journal."

In the present paper it is my intention to explain—firstly, the method of ascertaining the specific gravity of solids when in broken or crushed fragments; and secondly, to show how the knowledge thus obtained may be applied to a useful and practical purpose by the miner or ore-washer, by enabling him to judge, with almost absolute certainty and exactitude, whether or not the various parcels of ore he may be preparing for market are cleansed from their associated matrix and gangue, and brought to their requisite standard of purity, and also of distinguishing betwixt the relative qualities of different parcels of ore.

The apparatus required are a good balance and a set of grain weights; a glass bottle, of about an ounce capacity, and a well-ground stopper; and a jug containing water at a temperature of about 60 deg. Fahr.—the other requirements being the bestowal of a due amount of care and attention. The process is conducted as follows:

1. A fair and dry sample of the ore to be tried having been taken, a small quantity (say 200 or 300 grs.) is carefully weighed out of it.

2. The glass bottle having been perfectly filled with water, the stopper replaced, and all adhering mixture wiped off, is also carefully weighed, and its weight added to that of the ore.

3. A portion of the water having been emptied from the bottle, the ore is poured, without waste, into it, and, after having been well shaken to drive off the air-bubbles contained in the ore, the bottle is again filled with water, the stopper replaced, and the whole reweighed together.

4. The weight of the bottle of water and ore in it is subtracted from the combined weights of the ore (No. 1), and bottle of water (No. 2), the difference showing the bulk of water displaced by the ore.

Lastly.—If the weight of ore is divided by the difference or loss, the quotient will represent the specific gravity of the sample tried.

For example:

	Grs.
A sample of dressed Cardiganshire silver-lead ore (galena) weighs	200.0
The bottle full of water weighs	644.4
Combined weight of bottle of water and ore	844.4
Weight of bottle of water containing also the 200 grs. of ore	816 7
Difference or loss	27.7

Then, 200 ÷ 27.7 = 7.22, the specific gravity of the ore tried.

I have appended to this paper a list of the most frequently occurring ores, and the specific gravity of each description when naturally and chemically pure. By referring to this table, it will be found that the density or specific gravity of pure galena (sulphide of lead) is 7.5 therefore as we have in our sample only succeeded in obtaining a density of 7.22, we not only know that the ore is not perfectly clean, but we also know approximately, and by a simple and expeditious process, to what extent the sample stops short of the highest degree of purity attainable by washing processes. So practically serviceable is the method, that in the supervision of the mines under my control I am constantly in the habit of using it as a ready means of distinguishing between the well and badly dressed samples, and the relative qualities of the various ores prepared for sale. As the density of a pure ore or mineral remains constant under all circumstances, it follows that when the specific gravity of a body is known the miner can, if he has any doubt as to the identity of any particular ore, form a

pretty correct conclusion as to what a substance is, or is not, by means of its specific gravity alone. For instance, supposing it to be difficult to distinguish by the eye betwixt the small crystals of tin and those of blende, an appeal to the specific gravity of each would alone be sufficient to settle the question, the density of tin ore being 6.5, whilst zinc-blende is only 4.0 times that of water.

The following table gives the specific gravities of some of the most important of metallic ores.

Name of substance.	Spec. grav.
Antimony—Native	6.6
Oxide	5.56
Sulphide	4.6
Arsenical	6 2
Antimonial—Nickel	7.5
Arsenic—Native	5 7
Yellow sulphide	3.48
Red ditto	3.5
Arsenical—Pyrites	7 0
Iron (mispickel)	6.0
Barytes—Carbonate	4.29
Sulphate	4.3–4 6
Bismuth—Native	9.7
Blende	5.9
Carbonate	6.9
Sulphide	6.4
Cadmium—Sulphide	4 8
Cobalt—Arsenical	6.4
Black oxide	2.2
Bloom	3.0
Pyrites	6.3
Cobaltine	6.1
Copper—Native	8 5
Blue carbonate	3.5–3.8
Green carbonate	3.7
Chloride	4.4
Gray	4.7
Phosphate	4.2
Pyrites	4.1
Red oxide	5 9
Silicate	2.0–2.3
Vitreous sulphide	5.5
Gold—Native	14.–19.
Iron—Brown ore	3.9
Carbonate	3.0–3.8
Chrome	4 3
Magnetic	5.0
Pyrites	4.8–5.1
Red hematite	4.8–5 3
Lime—Carbonate	2.5–2.8
Tungstate	6.0
Lead—Native	11.3
Arseniate	7.18
Carbonate	6.46
Chromate	6.0
Molybdate	6.3–6 9
Oxide (minimum)	4.6
Phosphate	6.9
Sulphide (galena)	7.5–7.7
Sulphate	6.3
Tungstate	7 9
Manganese (wad)	2.5–3.7
Oxide	4 8
Spar	3.4–3.7
Mercury—Native	13 6
Chloride	6.4
Sulphide (cinnabar)	8.0
Molybdenum—Sulphide	4 5
Nickel—White arsenical	6.4–6 7
Glance	6.1
Pyrites	5.2
Palladium—Native	10.–12.
Platinum—Native	17.–19.
Silver—Native	10.–11.
Antimonial	9.4–9.8
Chloride (horn)	5.55
Glance (sulphide)	7.19
Ruby	5.7–5 9
Telluric	8.3–8 8
Strontia—Carbonate	3 6
Sulphate	3.9
Tellurium—Native	6.1
Tin—Oxide	6.5–7 0
Pyrites (sulphide)	4.3
Titanium—Oxide	4.2
Wolfram—Tungstate iron	7.0
Zinc—Blende (sulphide)	4.0
Carbonate (calamine)	4.3
Oxide	5.4
Silicate	3.4

In my next letter it is my intention to point out other useful and interesting facts upon the subject of "The Metals and their Ores."

A Travellers' Theodolite.—L. Casella, of London, is manufacturing a small transit theodolite, which is contained in a box 4 by 5 by $6\frac{3}{4}$ inches, outside measurement. It has a telescope, complete 3 inch horizontal and vertical circles with verniers reading to 1 minute, and can be used not only as a theodolite for terrestrial surveying, but also as an altazimuth for determining time, latitude, and azimuth astronomically. Its diagonal eye-piece admits of the observation of zenith stars easily. It has a reflector for illuminating the wires at night, a dark glass for solar observations, a finely divided level, a compass and apparatus for all the necessary adjustments. Such an instrument may be very useful to scientific explorers and engineers making preliminary reconnoissances in a new country.

The glass works of J. B. Ford & Co., New Albany, Ind., cover an area of 7 acres. They give employment to 200 hands, and turn out over 1, 600 boxes of glass per week. Among their products is rough plate glass for sky lights, floors, etc.

IMPROVEMENTS IN RAILWAY CONSTRUCTION.

From "The Mechanics' Magazine."

One of the greatest branches of civil engineering—we use the adjective in its literal not in its technical sense—possesses an aspect in the present day which is the very antithesis of some departments of modern construction for purposes of warfare. While, on the one hand, we see each year larger iron-clads laid down on the stocks, and bigger cannon constructed with which to arm them, a remarkable change is coming over the dreams of the older railway engineers, and if ever a technical question was promised searching investigation in all its bearings surely the question is railway engineering. While one class of engineers are emulating each other in building or proposing big guns or big armor-plates, many of their brethren, whose labors are to promote commerce instead of improving munitions of war, are devising every conceivable scheme to diminish the cost of railway construction.

When the railway principle was first embodied in anything like a national line we got the Great Western with a gauge of 7 ft.; even at that early period, however, in the system a powerful opposition was made to the adoption of an arrangement that demanded so large an outlay. Since then every effort has been made to render the principle of traction on rails subservient to the needs of commerce in less expensive fashion than even the cheapest existing railway exemplifies. The cost of the mere rails themselves, although an important feature in the maintenance bills, is one quite apart from those heavier outlays represented in huge earthworks and colossal bridges. So energetic are these efforts that nearly every conceivable gauge is proposed, from the existing and popular 4 ft. 8½ in. down to what we must, at the risk of being accused of perpetrating a bull, designate as no gauge at all, and represented in a patent lately secured in which a single rail is intended to be employed.

Commerce, to benefit all its votaries in a like degree, must have uniform facilities for its operations. It is to no purpose that one man has as valuable goods to sell as another, unless he can bring them to market as quickly, in as good condition, and at as small an outlay. Perhaps the most valuable commodity since the advent of railways is time. Never was there a period when the "first come first served" maxim obtained so completely as the present; this question of time affects all alike, because the most rapid commands all other transactions. The necessities of this principle apply to colonies as well as to old countries, to outlying provinces as well as to leading centres of commerce, and until colonies are supplied with the same, or nearly the same, means of intercommunication, they cannot deal on equal terms with such countries as already possess them.

When the railroad question is considered in its bearings as provided for the purposes of new countries it contrasts favorably even with common roads. This may at first seem a startling assertion; nevertheless it is a true one. A road, in the generic sense of the expression, is simply a device by which a load is sustained and which admits of that load being moved over it with a certain tractive force.

Examining the power to sustain we find it is simply a question of area. If a wheeled carriage with tyres (say) one inch and a half wide is placed in soft mud it at once sinks till a firmer bed is reached; if it be set on planks laid over the surface of the mud, then it rests secure because of the larger area. This appears trite, but nothing is so trite as an established principle, yet without principles engineering would perish. Now a rail is simply a girder, neither more nor less; if, then, we can lay along the ground a succession of girders properly provided with base area proportionate to the nature of that ground and the magnitude of the load to be borne, we have the railway principle at once embodied. The common road is another affair; in it we merely labor to thicken or stiffen the mud to such consistency that it may be able to prevent the wheels sinking therein; but in moving the carriage over this road there is no provision to secure the progress of the wheels in a straight or a uniform direction; therefore the road must have large margins for lateral deviation.

The leading reason why the railway principle develops so slowly at present in new countries, and even in thinly populated districts in old ones, is that it is so persistently regarded as the exponent of the most advanced civilization and, consequently, we fall into the habit, when thinking or discussing questions of railway construction, of picturing to our imagination palatial stations, 40-ton engines, saloon carriages, and a speed of 50 miles an hour. Happily, we are beginning to break through this narrow view of a great principle, and are learning to take a more extended one. Many a clever engineer would be startled if told that in certain places, and those the least of all adapted for a railway according to human wisdom, are the places in which Nature has herself provided such facilities that a few men with hatchets can in 3 or 4 weeks construct a length, to be measured in miles, of a road to all intents an excellent railroad capable of conveying goods, and, if a little additional care be exercised, passengers also with speed and safety. An example of such a line is to be found in Italy, where the wood lumberers, as the Americans would call them, lay down trunks of trees side by side longitudinally in the direction of the road; if on the ground, well and good; if a precipice intervene, then shallow steps are cut in the face of the cliff and transverse bars are laid projecting out like brackets and sustained at the outer extremities by thrust members, roughly recessed into the horizontal cross timber at one end and into the face of the rock at the other. Then on these the trunks of trees are laid longitudinally, as on the ground, and so arranged that the small ones are at the centre and the others increase in size to the sides of the road. This is simple enough, but something is still wanting to complete the line. The next process is to throw water on this timber roadway, which speedily freezes; then more and yet more water till a stout veneer of ice is formed, and which, from the large trees being outside, is in hollow or depressed in the centre of the cross section of the line. Where there is a curve an additional stick is placed as a guard rail outside and resting on top of the outer stick. Here, then, the Italian lumberers have provided a regular tramway, down which they send their timber balks, the speed being sometimes as much as 20 miles per hour, the line throughout being on a considerable inclination from the woods at the base of the Alps down to the valleys below. The timbers being started at the one end, slide like a ship when launched from the stocks right away to the other end. From this we perceive that it is possible to embody a principle without elaborating a mass of scientific matter, which, however valuable in other circumstances, is inapplicable to railway-making in the Bush.

As one example of how our habitual method of regarding the railway question cramps its application in a rough way, is the question of gauge. To this day, whenever a novelty in railroad construction, apart from mere questions of permanent way, is under discussion, the word gauge is as sure to turn up as King Charles's head did in Mr. Dick's memorial. Even the roughest tramway is laid to a gauge, very properly of course, where the doing so does not involve any particular point of trouble; but did any enterprising individual ever yet think of whether a line might be made without the presence of a skilled supervision to see that the rails were of a perfectly uniform distance apart? This necessity for care in laying the rails is one obstacle, or is made one, to the construction of rough railways. Another perhaps as serious grows from it, and is found in the necessity for, in some sort, special vehicles. Now there is no reason why this last evil may not be greatly diminished, and we would suggest the principle of making one of each pair of wheels to run loose on the axle and to have liberty of movement on it in the direction of its length; of course the wheels would need double flanges, but it is as easy to have two as one. With vehicles of this nature a line with light rails could be laid down in places where timber was at all plenteous with great dispatch, and at less cost than a macadamized road could be constructed, while at the same time furnishing the germ of what as the country progressed could be gradually elaborated into a first-class railway. Doubtless, the loads on such a line should be light, therefore they could but at first be the means for any wheeled carriage drawn by a horse to pass over, and be improved afterwards.

GRADING of the Utica, Clinton, and Binghamton Railroad is completed.

NAVAL GUN CARRIAGES.

From "The Engineer."

A little problem for mechanical engineers :—Given one of the Peninsular and Oriental Company's steamers, say 3,000 tons burthen, also a heavy sea, also a tank locomotive, weight 35 tons, mounted on the upper deck of said Peninsular and Oriental Company's steamer ; locomotive to stand across the deck, with the smoke box toward the bulwark ; required :—means for running said tank locomotive in and out through a distance of 6 ft., also means for training the after end of said engine through an arc of 80 deg. without going half an inch in advance of, or stopping half an inch behind, a given point ; also means for lifting said tank engine bodily through a height of about 2 ft. ; also means for lifting first the rear, and afterwards the front end of said tank engine, so that a line passing through the centre of the boiler can be ranged through 16 or 18 deg. of arc—all to be done, be it remembered, in a heavy sea, the ship pitching and rolling the while. We believe we shall not wrong the members of our profession if we state that there is not a man among them who would not shrink from solving the problem, if any could be found who would, just at the first sight of the thing, admit that it could be solved at all. But there is no doubt whatever that the problem can be solved. The working of a 35-ton gun, weighing with its carriage and slide at least 42 tons, can be managed on board ship, and it is not less difficult to manœuvre a 35-ton gun than it is to manœuvre a 35-ton locomotive. In point of fact it is more difficult, inasmuch as the gun has to stand charges of 120 lbs. powder, and a shot weighing over 6 cwt.—three shots to the ton! and the enormous recoil due to the firing of this charge has to be taken up and disposed of within a moderate distance, say 6 ft. or 7 ft., and the powder has to be put into the gun, and the shot lifted some 5 ft., and put in after the powder, and the gun has to be raised or depressed, and trained round ; and all this must be done on a platform in violent motion, and at such a speed that two shots at least can be fired in every three minutes. This is the work the designers of modern naval gun carriages have to perform. The fact that they have performed it constitutes one of the most magnificent triumphs of mechanical engineering yet seen, if we take into account the limited space and limited power available.

The problem has not been solved by trained mechanical engineers ; on the contrary, as far as the British navy is concerned, it has been solved by a naval officer—Captain R. F. Scott. It is not to be supposed that mechanical engineers possessing a thorough knowledge of all the conditions to be fulfilled are unable to contrive means of working a heavy gun, in a sea way ; but, as a matter of fact, mechanical engineers do not, from want of opportunity or other causes, possess the requisite knowledge ; and as a result, the problem has been solved, we think we may say satisfactorily, by an officer who combines a rare knowledge of mechanical proprieties with a keen appreciation of what is and what is not wanted on board a ship. Certain it is that there is hardly a heavy gun in the navy which is not mounted, or about to be mounted, on a carriage embodying some one or more of Captain Scott's inventions ; while there is not a single gun in a British turret ship which is not mounted on a carriage designed throughout by Captain Scott.

We have referred in another place to the process of welding together the principal coils of the 35-ton gun now being made at Woolwich, a gun which, all going well, as we have reason to believe will be the case, will be the most powerful piece of ordnance the world has ever seen. In the carriage department of the Arsenal may be seen, in course of construction the carriages intended to carry this and three similar guns on board the Sultan. It would be very difficult to make the construction of these carriages clear without the drawings, which we hope to be able one of those days to place before our readers. It must suffice to state the nature of the work to be done, and of the means employed in doing it. First, the gun must possess the power of being raised and depressed through varying angles. Secondly it must possess the power of being run in to be loaded, out to be fired. Thirdly, it must possess the power of being turned right

and left through a large arc. If it is mounted in a turret this work is done by rotating the turret, but it is not indispensable that heavy guns should be mounted in turrets. There are plenty of 18-ton guns working on the broadside system, and there is no doubt but that a gun twice the weight could be so worked if it were found expedient. Fourthly, means must be provided for taking up the violent recoil due to the explosion of great charges of powder. Fifthly, means must be provided for lifting the whole gun bodily through a considerable height. We shall consider these five problems and their solution *seriatim*.

First, then, as to means of raising and depressing the gun through different angles. The weapon is mounted on trunnions and has a certain preponderance at the breech end, by which it is supposed to be always kept on a heavy screw supporting the preponderance. It may appear a very simple matter to design a screw which will deal with this moderate load in a perfectly satisfactory way; but in practice it is not found easy. Between the rolling of the ship and the violence of the jerk due to recoil, these elevating screws have always been troublesome affairs to deal with. They either go so stiff that great power is required to run them up, or they go so easily that the instant a charge is ignited they run down, and the gun must be depressed again before a shot can be fired with a chance of hitting the mark. This difficulty has been overcome, we shall not now stop to say how. It would be waste of space without drawings, which, as we have already stated, we hope ere long to be able to place before our readers. Next as to the means of running in and out. The gun is mounted on a carriage consisting of cast-iron distance pieces fixed between two heavy wrought-iron cheeks. This carriage rests on the "slide," an oblong frame of iron which is anchored, so to speak, by a Y piece to a strong pivot placed as close as possible to the porthole. This pivot acts as a centre, round which the slide traverses on small brass conical wheels or rollers running on "racers"—that is to say, a curved permanent way let into the deck. The slide is composed of a pair of very heavy wrought iron I girders, the spaces between the upper and lower flanges of which are filled in with teak. The gun carriage proper slides on the upper surface of these girders when recoiling, but when the gun has to be run out a lever is brought into play, which, acting on an eccentric, throws down rollers which take the weight of gun and carriage and permit both to be run out with great ease. As soon as the gun is out the eccentric lever is released, and the gun carriage then slides or skids on the upper edges of the two sides of the "slide." The gun comes in by the force of its recoil. It is carried out by turning a winch handle, which actuates an endless chain of flat links—just like a gigantic watch chain—kept taut by an ingenious arrangement of india-rubber springs. A clamp beneath the carriage can be caused to seize this chain at any time. The clamp is of course released when the gun is to be fired. The friction between the slide and the carriage is very great, but it is not alone sufficient to control the recoil. This is effected by the aid of two "bow compressers," one being sufficient for all ordinary purposes, and the other being used only in emergency. We could not make the details of this compresser clear without drawings. It will suffice to say that it resembles a boilermaker's horse-shoe cramp on a large scale, and that being fixed to the carriage it compresses the teak beams, let in on either side of the slide beams, between two flat plates of iron, by which so much friction is brought to bear that the recoil of the gun is readily controlled. Hitherto gun carriages have been made very high and the slides very low; the result is that no free access can be had to the slides or space beneath them, and that in washing decks, the water lies between the slides, and under the gun, rusting and rotting the machinery. In the second place the centre of impulse of the recoil being far above the centre of resistance of the compresser, the gun tends to kick off the slide, tipping up in front, or, in other words, rotating round the centre of compression. Captain Scott gets over both difficulties by reducing the height of the gun carriage, and increasing its length, while he raises the slide to make up for the space lost. The centre of impulse and resistance are thus approximated, and the tendency to tip is got rid of. Fourthly, we have to consider the means by which the slide is caused to wheel round through the requisite arc. This is effected by means of two wrought iron pinions,

gearing into a large bevel wheel at the rear of the carriage, and actuating an inclined shaft, terminating near the middle of the length of the slide. On this end of the shaft is mounted a pinion, which gears into a rack "racer" fixed on the deck ; by this means the slide can be traversed right or left with the greatest ease. But it has not only to be traversed, but held in place ; this last is effected by means of the most compact and ingenious break gear we ever saw. We do not exaggerate when we state that this brake complete does not weigh 20 lbs., and could easily be put in an ordinary hat ; yet it suffices to control an 18-ton gun in a heavy sea. Fifthly, and lastly, we have to deal with the arrangements for lifting the gun bodily. This is rendered necessary in turret ships by the small size of the port ; when great depression is wanted the whole mass of the gun must be raised, when great elevation is required the gun must be depressed. It is, in fact, partial muzzle pivoting. The raising and lowering are effected by hydraulic presses, constructed, we believe, by Messrs. Tangye, of Clement street, Birmingham. We reserve detailed description.

Now it is indisputable that all this beautiful mechanism—for it is, thanks to the skill of the Woolwich Carriage Department, thoroughly beautiful as regards workmanship, and, thanks to Captain Scott, not less beautiful in design as regards mechanical fitness for the discharge of its duties—has been introduced, worked out, and perfected by Captain Scott. We do not disparage the claims of other inventors ; we only deal now with absolute facts. Captain Scott has designed and superintended the manufacture of the only naval gun carriages found to answer in the British navy. It is not, indeed, too much to say that it is only because Captain Scott has labored we are able to work anything heavier than a 6-ton gun at sea. His work has extended over years. Both Admiralty and War Office are satisfied with the result, and yet he has never received the smallest recognition for his services from the Government. Is this as it should be ? We think not. The Government is not slow to reward when it pleases. Major Palliser has received £15,000 for the introduction of chilled projectiles. How is it that an officer who, without drawing invidious comparisons, has done much more than Major Palliser, goes not only without the smallest reward for his services, but (if we are not mistaken) without the repayment of a considerable sum out of pocket. We hope ere long to supply our readers with full details of the gun carriages in our most powerful ships ; we trust we may be enabled to state at the same time, that the labors of the designer of these carriages has met with the substantial recognition which he really deserves.

IMPROVED METHOD OF PRODUCING HYDROGEN GAS.

By C. WIDEMANN.

From the "Journal of Applied Chemistry."

It is well-known that carbon, either pure or combined with hydro-carbon, is decomposed at a temperature of orange red heat by steam, and that it produces hydrogen and carbonic acid, mixed with more or less oxide of carbon. It is also known that the hydrogen resulting from the decomposition of carbon by steam cannot, by the means at present employed, be produced economically ; first, because in the generation of steam, a great quantity of latent heat is absorbed. Second, because the vapor produced at a temperature of 100 deg. Centigrade, requires a considerable quantity of free heat in order to raise it to the temperature at which it will be decomposed, and this heat must either be taken from a special apparatus for superheating, or it must be furnished by the incandescent coal which it ought to decompose. Third, because the retorts containing the carbon which decomposes the water, when brought to a red heat, and exposed directly to the steam, soon becomes damaged and unfit for use. This being the case, MM. Tessie du Motay and Marechal, who have lately discovered a mode of obtaining cheap oxygen for illuminating and medical purposes from the manganates of soda, have sought a more practical and economical method of producing hydrogen by the decomposition of

water by means of carbon, and they have discovered the following method, which has given the most extraordinary results :

Alkaline, and earthy alkaline hydrates, such as the hydrate of potash, soda, strontian, baryta, chalk, etc., mixed with charcoal, coke, anthracite, pit coal, peat, etc., and heated to a red heat, are decomposed into carbonic acid and hydrogen, without further loss of heat than that due to the production of the carbonic acid and hydrogen.

The hydrates of potash, soda, etc., and more especially the hydrates of chalk or lime decomposed by the coal into hydrogen and carbonic acid, can be used indefinitely in this process, provided that they are moistened each time with water so as to reproduce the decomposed hydrates.

In this operation, the hydrogen gas is generated without any special production of steam, and may thus be produced without any other generating apparatus than the retorts themselves. These retorts not being exposed to the direct action of the steam, are not subject to any interior alteration or damage.

It follows, therefore, that the hydrogen gas produced by the decomposition of the above-named hydrates by means of carbon, can be generated at a very small cost, and with the same facility as carburetted hydrogens from the distillation of pit coal or other organic hydro-carbon matter.

These alkaline and earthy alkaline hydrates may be mixed with the different mineral or vegetable combustibles, either in a definite chemical proportion or without a fixed or determinate proportion, and in any suitable distillery or heating apparatus, in order to produce, when heated to a red heat, hydrogen gas for illuminating and heating purposes.

The advantage of the production of hydrogen as cheaply as oxygen has been obtained would create a revolution in many industries, and especially in metallurgy.

A cheap method of producing a great heat in order to reduce metals, such as platina, gold, silver, and iron, has been long sought for in Europe, where the oxhydric blow-pipe is now used to melt the platina in a calcium crucible. By this discovery it becomes possible to obtain an immense heat which could be regulated by a simple tap. Enamellers and porcelain makers would thus get rid of one of their greatest troubles. Let us hope that, as MM. Tessie and Marechal have fulfilled their promises in regard to oxygen, they will again be successful in their new discovery, and we assuret hem of our sympathy and interest in this matter.

INDIAN RAILWAYS.

From "Engineering."

It is now just twenty years ago since the first sod of an Indian railway was turned. At that time it was decided to confine operations to two small experimental lines, 150 miles in length, one of 120 miles in Bengal, the other of 30 miles in Bombay. In four years these were opened, but before that time arrived, Lord Dalhousie, then Governor-General, had proposed, and the home authorities had approved of the system of railways which is now approaching completion. At first, only three companies were employed to carry out works in each Presidency, but, subsequently, other lines were grafted upon the original system, and additional companies were formed. Thus, there are now nine companies engaged in constructing and working railways in India. The first section of line in India was 21½ miles, belonging to the Great Indian Peninsula Railway Company, which was opened in 1853. In the following year the East Indian Railway Company opened 37½ miles of their line, and in 1856 the first portion of the Madras Railway, 65¼ miles in length, was completed. By 1860, ten years after the commencement of railway operations in India, 836¼ miles were in working order ; in 1865 there were 3,368¾ miles opened, and at the present time the extent of completed railways in India is 4,628¼ miles in length. By far the greater portion of this consists of a single line only, the portion laid with double lines amounting only to 479 miles, of which 203 miles is on the main line of the East Indian, 256 on the Great Indian Peninsula, and 20 miles on the Bombay, Baroda, and Central Indian Railway. The most im-

portant event which has marked the history of Indian railways during the past year is the junction of the Great Indian Peninsula and the East Indian Railways at Jubbulpore, whereby the whole breadth of the Peninsula is spanned at its widest part, and Bombay and Calcutta, as well as Bombay, Delhi, and Lahore, are brought into railway communication with each other. The East Indian Railway has been opened to Jubbulpore since 1867, but unforeseen delay occurred in the completion of the works of the Great Indian Peninsula Railway, and the long desired junction of the two lines has been deferred in consequence. The works have lately been pushed on with great vigor and rapidity, and although there is still much to be done before the line can be considered thoroughly completed, it was sufficiently advanced to admit of the ceremony of opening being performed by the Duke of Edinburgh and the Viceroy on the 7th of March last. The occasion gave rise to proceedings of much interest in which the Governor of Bombay, the Chief Commissioner of the Central Provinces, Sir Sala Jung, the Minister of his Highness the Nizam, Maharajah Halkar, Maharajah of Rewah, the Rajah of Mijhere, and other functionaries took part. The line in question proceeds from Bombay up the Thull Ghaut *via* Jubbulpore to Allahabad, thence it follows the valley of the Ganges to Calcutta. Before the end of the present year a more direct route will be opened for the latter part of the line by the completion of the chord line of the East Indian Railway to Luckeserai, *via* Raneegunge, to Calcutta. The distance from Bombay to Calcutta by the present route is 1,470 miles. It will then be 1,400 miles.

The year 1869 saw the addition of 261 miles of railway to the already existing lines in India. At the close of 1868 there existed 4,017 miles of open railways, which was increased to 4,278 by the end of 1869. The addition during the year consisted of 30 miles on the northwest branch of the Madras line, and of 231 miles on the Delhi Railway. Since the end of the year a short branch of 8 miles, which has been constructed by Government, extending from Jhellum on the Great Indian Peninsula Railway to the cotton mart of Khamgaon, and 25 miles more of the Delhi line, have been opened, besides 69¾ miles between Sholapoor and Goolburga on the south-east branch of the Great Indian Peninsula Railway, and the Jubbulpore line before mentioned. The short extension of the Baroda Railway across the Saburmuttee river, and 2 miles beyond, was also opened on the 1st January last. The whole length of railway now open in India is 4,628 miles. The length of line at present sanctioned for construction in India comprises 6,249 miles, of which 6,005 miles belong to guaranteed companies; 216½ miles are State lines; and the Nulhattee, a subsidized line, is 27½ miles in length. There remain consequently 1,519½ miles yet to be finished. Of these several are on the eve of completion. The chord line of the East Indian will be finished in the course of this year. The line between Madras and Bombay, with the exception of the bridge over the Kistna, should also be opened next cold season. The Delhi line will probably be completed. The Oude and Rohilkund Company will open their first section beyond Lucknow, and the extension of the Eastern Bengal Railway to Golundo will, it is expected, be ready for opening in the course of the current year. Progress has also been made with the Punjab State line, which, with the exception of a few divisions, is to occupy one-half of the trunk road. The lines which form the system of railways for Oude and Rohilkund have now all been sanctioned and staked out, and the earthworks have been formed over many miles. The bridges also have been put in hand, and permanent way material taken to different parts of the line. The Bombay, Baroda, and Central India, and the Great Southern Railway Companies have made every preparation for carrying out with vigor the extensions committed to them; and the Carnatic Company, which has taken the place of the former Indian Tramway Company, is making the surveys for the extension of the line to Cuddalore, and is about to convert the narrow gauge line between Arconum and Conjeveram into a first-class railway with the standard gauge of 5 ft. 6 in.

With regard to lines in the hands of Government, and which are termed "State Railways," one—the Calcutta and Canning Town—was surrendered by the company which constructed it to the Government; another—the Jhellum and Khamgaon—was executed under the directions

of Government officers in the space of nine months, and is being worked by the Great Indian Peninsula RailwayCompany; the third, viz., the Lahore and Peshawur line, is being laid out and constructed under the superintendence of Mr. Lee Smith. The lines which are now being surveyed by the Government in view to their early commencement are 1st, from Delhi, in a southerly direction, to Rewaree, with a branch to Furrucknuggur, where valuable brine springs exist; 2nd, from Agra to Sambhur salt lake, and on to Ajmere, forming a junction at some point to be determined on with the above-mentioned line from Delhi; 3rd, from Mooltan, by the valley of the Indus, to Rohree; 4th, from Koolburga to Hyderabad; 5th, from Karwar to Hoohlee. No estimates have yet been made of the cost of the lines to be undertaken by Government, nor has it been considered necessary to make any special provision for the raising and issuing of money for the purpose. The line between Goolburga and Hyderabad, above mentioned, is in one sense a State line, although not paid for by the Government. The gratifying announcement has lately been made by the Government of India that Sir Salar Jung, the chief minister of H. H. the Nizam, has engaged to provide a million of capital for the construction of this line, which is to be executed and managed by the Indian Government for the Nizam. The Government have at the same time communicated the fact that H. H. the Maharajah Holkar has also arranged to advance a million sterling for the branch to Indore from the Great Indian Peninsula Railway, the British Government allowing him 4½ per cent. interest upon the loan, and dividing with him ratably, on the share of the outlay contributed by him, the profits over and above that rate.

The 4,628 miles of railway which are now open in India, have cost about £79,000,000. The total amount expended up to 31st March last amounted to £83,444,147, but this includes the cost not only of the open portion, but also of many miles still in course of construction. The gross receipts last year were £5,709,382 as compared with £5,320,723 in the previous year, and the net receipts were £2,520,952, and £2,522,622 in the two years respectively. The railways were thus earning last year at the rate of about £3 4s. 6d. per cent. per annum on the capital expended on them, £1,380,000 short of the guaranteed interest payable on such expenditure, and £1,412,919 less than the amount paid for guaranteed interest on the whole capital raised, including that employed on unopened lines and the unexpended portion as well. The number of passengers carried during the year was 16,011,633, compared with 15,066,530 in the previous year. The amount of goods traffic was 2,588,513 tons. The train mileage was 12,318,086 last year, and 11,980,319 the the year before.

ON CERTAIN PROPOSED IMPROVEMENTS IN THE MANUFACTURE OF HYDRO-CARBON OILS.

From "The Mining Journal."

Mr. David Cowan read the next paper on the subject stated above. He said:—The importance to which the manufacture of mineral oils has attained during the past few years is such as to give it a place among our leading local industries. The oil-yielding materials—that is, the bituminous shales and the cannel coals—are plentifully distributed throughout the whole of the Scottish coal measures, but differ very much in character, both as regards the quantity and the quality of produce. To obtain oils from these materials, they are, first, subjected to a process of destructive distillation, which forms the oils, during which they escape in the form of vapor, while the fixed carbon remains with the ash in the distilling vessel or retort. The economy and efficiency of this operation depend greatly upon the kind of retort, the system of heating adopted, the degree of heat applied, and the efficiency of the condensing part of the apparatus. Various forms and arrangements of retorts have been tried from time to time with more or less success, but full descriptions of all the retorts and ovens that have been tried is not contemplated in this paper. The retorts used in this district belong to either one or other of two types

—the horizontal and the vertical. The horizontal retort is usually rectangular or elliptical in cross section, and varies from 30 to 60 in. in width, and from 8 to 10 ft. in length. They are built in brick-work, and are heated, charged, and emptied much in the same way as the retorts used in the manufacture of coal gas—only a much lower degree of heat is applied. The vertical retort usually consists of an upright cylinder, fitted at the top with a hopper and bell-cone charging apparatus similar to that used on a close-topped blast-furnace. The lower end dips into a trough of water, which, while it admits of the exhausted materials being withdrawn there, prevents the escape of the hydro-carbon vapor, and also the entrance of air into the retort. It is proposed in this paper, first to consider the advantages and disadvantages of each of these classes of retorts, and afterwards to describe an arrangement of apparatus designed to combine the advantages of both, and which at the same time will admit of improved facilities for working. In horizontal retorts the depth of the charge of material is very much less than in vertical retorts, and the passage of the oil vapor through the material to the surface is, therefore, comparatively easy. The outlet pipes are generally at the end of the retort furthest from the furnace, and would be upon a level with the upper part of the material of the charge, and the unobstructed vapor escapes freely, which is greatly conducive to a good yield as well as to a good quality of oil. The vertical retort is generally about 10 ft. in height, and is completely filled with shale up to the mouth of the discharge pipe. The passage of the vapor from the lower portion of the retort is considerably obstructed by having to pass through such a depth of material, and there is much loss by condensation in the upper part of the retort before the vapors reach the exit pipe, and in consequence of the condensation the vapor falls down into a hot part of the retort, and is again exposed to a temperature equal to that at which it was formed, and partly decomposed, and is deprived of a portion of its hydrogen. There is thus caused a deterioration of the quality and a diminution of the quantity of light or burning oil. Altogether the oils from these vertical retorts are of inferior quality, as compared with the produce of horizontal retorts, while the quantity of uncondensable or permanent gas is increased. The work of charging and discharging these retorts is, however, considerably less. The arrangement herein to be proposed and described belongs to the vertical class, with improvements calculated to remedy the evils we have been describing as attaching to them. The writer went on to illustrate by a series of diagrams the operation of the retort, which was charged from the top, the bituminous materials in small pieces being put into the annular spaces between the grating and the inside. When heated to a proper temperature—say, between 700 deg. and 800 deg. Fahr.—hydro-carbon vapors are formed and given off. These find their way into the grating pipe—the coolest part of the retort—and when assisted by the exhausting fan will speedily find their way through the eduction pipes into the condensers. Thus the thickness of shale through which any of the vapors must pass before reaching the outlet pipe is only the width of the annular space—say, 8 in. In this form of retort the vapor does not require to ascend at all, and although it may partially condense within, it cannot return to the hottest part, but must pass downwards towards the condensers, and, therefore, whatever loss is due to the decomposition which is usual from this cause will in a great measure be saved. It appears to the writer that another important improvement may be effected in the way of heating or firing the retorts. In heating them by ordinary coal-burning furnaces, constant, regular, and watchful attention to the condition of the fires is required. The regular maintenance of the proper temperature may be said to embrace the whole of the skill required for distilling crude hydro-carbon oils. It has occurred to the writer that, instead of firing with coal, the retorts should be heated with gas flame, as, besides economizing fuel and labor, it will meet the requirements of regularity and watchfulness more satisfactorily than the present system, as when once the gas is lighted and the flame adjusted, further attention will be unnecessary. It is here suggested that the system of first converting the fuel into gas (so successfully worked out by Siemens) should be adopted, and the drawings show generally how such a system can be applied. They also show the arrangement of

the flues and indicate the direction of the currents. Inspection will show that the air necessary for supporting combustion will be heated previous to entering their furnace. This mode of heating by gas instead of by solid fuel, and with hot air supplied to the furnaces, should, besides the more important advantage of regular temperature, effect a saving of from 40 to 50 per cent. of fuel. The author has also directed his attention towards economizing the labor required for charging and discharging these retorts, and with this object in view he has designed an arrangement of machinery for serving the materials to the retorts, as shown in the drawings. In describing the action of the machinery, the steam-engine used for working the pump and fan would communicate motion to the end pulley or wheel. The motion should be adjusted so that the chain will be moved over the pulleys at a speed of about three miles an hour. The empty buckets as they reach the loading bench, on a level with the surface, are filled with material, and are afterwards carried by the moving chain upwards and along above the top of the retorts ; and at whatever bench it is desired to empty these buckets a pin is to be inserted into the eye-hole formed in the arms V V, which engages the arms U U on the bucket, and tilts it in the manner shown on the drawing. When emptied, these buckets immediately right themselves, pass onwards and round the far end wheels, and return to the top line of chain, to be again filled at the loading bench. The mineral, when deposited on the top of the benches, can be conveniently raked into the mouths of the retorts, or may be so arranged as to empty direct into the retorts. The same apparatus will convey the coal drop to the gas generators. This machinery might be simplified by using only one endless chain, or by adopting a modification of the wire tramways ; but the arrangement here proposed is preferred where large quantities of materials require to be operated upon. The drawings show a tramway laid along the front of the retorts, which is provided with turn-tables for running small wagons into openings, W W, which are formed in the backwork underneath them. The potters which secure the bottom covers are withdrawn, by a portable screw apparatus, worked from the outside. The bottom then falls down and the exhausted shale empties out of the retorts into the wagons underneath, by which it is conveyed to the refuse heap. Thus the work of charging and discharging is reduced to a minimum. The arrangement for discharging the retorts is as follows : Each pair of retorts are connected at the bottom by a horizontal tube, on which are cast two brass sockets or faucets, for receiving the bottom ends of the retorts. The ends are closed by covers, one of which is a fixture, and is provided in the centre with a stuffing-box. The other centre can be removed at pleasure. A shaft is fixed along the axial line of this horizontal cylinder, on which are fixed two screen blades, one under each retort. These are revolved by suitable gearing, and will discharge the spent materials into a small wagon, resting on the tramway in front of the benches. This would be a more expensive arrangement, but the advantage which it has over that previously noticed is that the shale is discharged in front instead of underneath, and that the workmen will not be so much exposed to the noxious gas which is discharged from the used-up materials. A simple defective stop-valve for fitting on to the eduction pipes is also much wanted in mineral oil works. The majority of such valves in use are either plug-valves or hydraulic cup-valves, worked by a rod passing through a packing box in the valve-chest cover. Plugs are seldom tight, and generally there is also a leakage from packing boxes. Cup-valves are always tight in themselves, but still they are liable to leak at the stuffing boxes. The condensers are riveted sheet-iron tubes, about 15 ft. long and 2 ft. in diameter, placed upright in a wall of brick-work, and have a central tube running throughout their entire length. The annular space between the outside and inside tubes should not exceed 3 in. in width. The joints which connect the gas and oil exit pipes are all secured by hydraulic seals, and provision is made for maintaining a constant depth of the sealing liquid around them. The oil main is placed underneath the condensers, and rests in a niche formed in the supporting wall. A 2 in. pipe runs along the bottom of this oil main, into which hot water or steam from the engine boiler can be poured at pleasure. This completes the description of the arrangement of plans which

form the subject of this paper. The details have not been minutely gone into, all that was intended being merely a general description of the modifications proposed, and this may be sufficient to induce discussion, and be the means of directing further attention to this object on the part of our Institution.

THE PRACTICAL APPLICATION OF THE CHRONOSCOPE.

From "The Mechanics' Magazine."

In our second notice of the Conversazione of the Institution of Civil Engineers, which appeared in our issue for June 10 last, we described the highly ingenious chronoscope invented by Capt. A. Noble. One of the uses of this apparatus we there stated to be the recording at one observation the velocity with which a projectile passes different points in the bore of a gun. But it has other practical applications, which we also there promised to place before our readers, together with some of its working results. Before proceeding to fulfil that promise it may be as well briefly to revert to the apparatus itself, and to note what has been previously done in this direction. About 130 years since, Robins invented the ballistic pendulum for measuring the velocities of projectiles, and as late as 1854 Colonel Boxer stated in his treatise on artillery that the experimental data afforded by the ballistic pendulum formed the basis of the whole science of artillery. Since then we have had Major Navez's electro-ballistic apparatus, which was improved upon by Colonel Lewes. This instrument, and also that of Major Benton, have been superseded by the chronographs of Professor Bashforth and Captain Schultz. These instruments, however, only measure the velocities after the projectile has left the gun, but by Captain Noble's apparatus we can measure velocities within the bore. Then with regard to the relative pressures on the gun it was thought a great achievement not long since, when these were obtained by screwing pistol barrels into the metal and measuring the velocities of the balls forced from them by the gas. Rodman's pressure gauge for showing the actual pressures, in which a knife is driven into a copper plate, has now given way to a new crusher, of which we shall presently say more.

The chronoscope consists of a set of discs fixed on an axle, and which are set in motion by a heavy weight, their relative velocity being regulated by a train of wheel gearing. Hollow plugs are screwed into the barrel of the gun at intervals, and pass from the outside of the weapon to the interior of the bore. As the projectile passes each plug in succession it presses a cutter which projects from the plug into the bore, and cuts a wire passing through the plug to the outside of the gun. Each of these wires is the primary wire of an induction coil, and its rupture causes a spark to pass between the secondary wires, which are connected each with the revolving discs, the edges of which are covered with white paper coated with lampblack. The spark burns away the lampblack at the point of discharge, and the white spots thus formed indicate the velocity of the projectile between the several plugs in the gun. So far the arrangement for taking velocities and for noting the powder pressure on the projectile. For ascertaining the strain of the powder on each part of the gun a number of steel plugs are screwed into the barrel from breech to muzzle. Each of these plugs contains a small solid copper cylinder, which rests against an anvil fixed in the plug, while a movable piston rests against the end of the copper. These are the crusher gauges, and they act in the following manner: When the charge is fired the gas presses on the piston and crushes the copper cylinder against the anvil. The effect of any given compression can be ascertained by a testing machine, so that the amount of compression sustained by the copper becomes a direct indication of the pressure of the gas. This crusher has been proved to be far more accurate than the Rodman gauge.

With these ingenious arrangements the committee on gunpowder and explosive substances have been enabled to construct time curves and velocity curves showing the motion of a projectile in the bore of the gun with various kinds of powder, and pressure curves showing the strain of

each kind of powder on the various parts of a gun. The rate of motion of the shot in the gun under every change of condition, and the strain on the gun at every point, can now be accurately mapped out on paper—a result never before attained with anything like real exactitude. It is satisfactory to find that these great strides in science are not barren of practical results, but that on the contrary they have proved highly useful and instructive. The committee above referred to have issued a preliminary report from which we learn some interesting particulars. From their experiments the committee have ascertained that in the 8-inch gun, with which their trials were made, a certain kind of powder known as "pebble powder, No. 5," gives, when compared with rifle large grain service powder, some remarkable results. This powder is made by breaking down press cake of a density of 1.80 into lumps of a certain size, which are afterwards finished in the usual way, occasioning but a very slight departure from the ordinary course of manufacture. A charge of 35 lbs. of pebble powder gave 50 ft. more velocity to the projectile on leaving the gun than a charge of 30 lbs. of R L G powder, and yet exerted only about half the strain upon the gun. We cannot overestimate the value of this result, especially as the advantage in velocity was fully maintained when battering charges were fired with the two descriptions of powder from a 10-inch gun under proof with 400 lbs. projectile. There is, in the first place, the great advantage that while maintaining and even increasing the present velocity of our projectiles for battering purposes, the use of the pebble powder will materially reduce the initial strain exerted by the exploding charge, thereby prolonging the life of the gun and diminishing the risk of accident. In the next place, it appears probable that the reduction in violence of explosion effected by the use of such a powder will diminish the liability of projectiles to break up in the gun, and also modify the scoring action of the gas upon the surface of the bore. Finally, there is a probability that another important advantage will be secured, namely, the attainment with safety of a considerable increment in velocity with heavy guns, whereby a material increase will be effected in the power of our armaments.

From the report in question we learn the action going on inside our heavy artillery, and we can trace the effect of the powder, not only upon the projectile at every point of its flight from the breech to the bore, but upon the gun itself at every part until the projectile leaves the bore. Incredible as it may seem, these are only simple matters of fact, and are effected by means of the apparatus we have been describing. All kinds of powder can now be compared, and have been compared to a good purpose as we have seen, and in this the committee have done good service so far as they have gone. In their memorandum of instructions their attention was specially directed to the importance of an early determination of the description of gunpowder, the employment of which in large charges is attended with the least risk of overstraining the guns, and they were desired to report progress from time to time. Up to the date of their report they, therefore, gave their attention specially and almost exclusively to this branch of the inquiry. As we have seen, they have made sufficient progress to prove that there is no difficulty in producing a description of powder much better suited for guns of large calibre than the present service powders. We understand that this pebble powder is being manufactured at Waltham Abbey, and we congratulate the committee upon the success which has attended this branch of their investigations.

The Lewistown, (Pa.) "Gazette" says: Glamorgan Furnace turned out 489 tons of pig metal during the month of June, and is now filling an order of 800 tons for the Cambria Iron Works. Weep, True Democrat, weep—your British nobles have lost a good job, and British pauper laborers a good deal of work, for this iron will be made into American rails! What a terrible nabob Mr. Morrell must be to give all the main products of this work to owners of American ore, American workshops, and American workingmen, when he could buy the articles ready made in England, Wales, or Scotland, cheaper than he can get it made here!

The new agricultural works at New Cast'e have at present 1,000 new machines in the course of construction.

IRON AND STEEL—A VERY COSTLY AND VEXATIOUS FALLACY.

Contributed to "Nature," by W. MATTIEU WILLIAMS.

I.—"A friend of mine has been converting some common cinder pig-iron into either very fine iron or steel by a very simple process, but does not know who to apply to to learn its value. He is willing to share the profit with any one who will help him in the matter. I have some small samples of it if you would like to see it, or can tell me who would be likely to interest themselves in the matter. From what I can make out I should think it would make good steel, for it will harden and temper now."

The above, quoted from a letter I have recently received, is a typical sample of a number of others I have had at different times, and it represents the labors of quite a multitude of patient, long-suffering, and miserably deluded investigators. The published specifications of abandoned patents make painful record of wasted money, time, and ingenuity; and suggest dark tragedies, of ruined hopes, all arising from the same misunderstanding of the changes which take place in the conversion of *ordinary* pig-iron or cast-iron into *merchantable* steel.

The most humiliating feature of this delusion is that it is not the offspring of popular ignorance, is not prevalent among the beer-drinking class of iron-workers, who sign their names with a +, but crops out among intelligent self-taught men, who have studied the chemistry of iron and steel as expounded in recognized chemical books. The costly fallacy I allude to is directly traceable to the teachings of our highest scientific authorities. As "Nature" is now largely circulating among the class of self-taught and energetic men who supply this ever-recurring crop of victims, and also among those who most unwittingly and unwil'ingly have deceived them, there can be no better medium through which to effect the demolition of this mischievous error.

By reference to almost any text-book on chemistry, it will be found that cast-iron is described as a compound or mixture of iron and carbon; that steel is another compound or mixture of iron and carbon, but with a less proportion of carbon; and that wrought iron is nearly free from carbon. Further, we are told that the ordinary method of making steel is, first to remove all the carbon from the cast or pig-iron by making it into wrought or bar-iron, and that this bar-iron is afterwards converted into steel by causing it to take up a new dose of carbon in the cementing furnace. The natural inference of a thinking reader is, that this is a clumsy complication, especially if he knows that the process of cementation is slow and costly, that on account of the irregular diffusion of the carbon in the blistered bars, other expensive processes of shearing, tilting, casting, etc., have to follow. Why not at once produce the steel from cast-iron by a process of decarburization which shall stop at the right point, *i. e.*, when the 3 or 4 per cent. of carbon of the cast-iron is reduced to the one or one and a half per cent. required to produce steel? By doing this not only the cost of converting wrought-iron into steel, but also the cost of puddling to produce wrought-iron will be saved; and steel, which is but a carburet of iron intermediate between cast and wrought iron, instead of being so much dearer than either, should be made at an intermediate cost, or cheaper than wrought-iron.

If he dips further into the literature of the subject, and reads the history of the manufacture of iron, he will find further confirmation of such reasoning, as he will learn thereby that the direct production of steel is an ancient art, and that weapons of renowned quality were made from steel thus produced.

By reference to one of the most recent and elaborate English treatises on the subject, Dr. Percy's "Metallurgy," he will find on page 778 that this is described as "the ancient method, which is still extensively practiced on the continent, especially in Styria;" and further down on the same page that "if steel be regarded simply as iron carburized in degrees intermediate between malleable and cast-iron, then it is obvious that the latter during its conversion into the former in the processes of fining and puddling, must pass through the state of steel." On page 805 of the same work he will find further confirmation of his theory in the words, "it is obvious that steel must be produced by

melting malleable and cast-iron together in suitable proportions."

I might multiply quotations from this and every other work I have seen in which the chemistry of iron and steel is treated, and show by each one of them that the thousand-and-one of unfortunate inventors who have struggled in vain to make steel directly from English pig-iron, have been encouraged in their delusion by the teachings of high chemical authorities.

"If steel be regarded simply as iron carburized in degrees intermediate between malleable and cast-iron," these inventors are perfectly justified in seeking some substance which at the melting heat of cast-iron shall give off a definite quantity of oxygen; and they have logical grounds for believing that by bringing such a substance in contact with the molten cast-iron, and properly regulating its quantity, they may burn out just that surplus carbon which makes all the stated difference between cast-iron and steel. As a multitude of compounds when thus heated do give off oxygen, a vast field of effort is open, and accordingly every available peroxide and decomposable oxygen salt has been administered by strange devices to the melted iron, the same obvious substances used over and over again, and the same failures continually repeated by expectant inventors ignorant of what each other have done or are doing. Gas and vapors have been blown over the surface and under the surface, and through from bottom to top of melted cast-iron, and all (including Mr. Bessemer) have failed to produce merchantable steel from ordinary English cast-iron, without first making it into malleable or wrought-iron.

The reason of this is, that the removal of the surplus carbon is only a small portion of the work which has to be done in order to convert cast-iron into steel of any commercial value. Several other substances have to be removed also; *and no process has yet been discovered by which these impurities can be removed without at the same time removing the carbon in corresponding degree.* I put this in italics because I am convinced by experience of its great practical importance; because I do not find it clearly and distinctly enunciated in any general or special treatise; and further, because I have seen so plainly that the want of clearly understanding it is the rock upon which so many unfortunate inventors have split.

These inventors have not been informed with anything like the necessary degree of distinctness, that the Styrians and others who have made or are making steel directly from cast-iron, have started with a very different material to that which bears the same name of cast-iron in England; the difference being sufficiently great to alter totally the conditions of the problem. The cast-iron of the Styrian steel-makers is a nearly pure carburized iron; *our* cast-iron is a carburized, silicized, phosphorized, and sulphurized iron; *their* problem in steel-making is merely the partial decarburization of their cast-iron; *ours* is the total desilicization, the total dephosphorization, and the total desulphurization in addition to this. Now, the partial removal of carbon from iron is one of the very easiest problems in practical metallurgy, while the complete removal of silicon, phosphorus, and sulphur, is among the most difficult.

To illustrate the grossness of the fallacy which represents the difference between cast-iron and steel as merely, or "essentially" due to carbon, I may state that on looking down a tabular statement of the analysis I have recently made of thirty brands of ordinary English pig-iron (excluding hæmatite pigs), I find that seven among them contain less than 2 per cent. of carbon, or an average of 1.77 per cent. Now this is below the percentage of carbon which exists in some of the finest and most expensive samples of cast-steel. Therefore, to convert these particular brands of cast-iron into the finest steel, the carbon must neither be increased nor diminished, and if, as Dr. Percy says, the differences between steel, wrought-iron, and cast-iron, "*essentially* depend upon differences in the proportion of carbon," all these brands of pig-iron should be described as steel rather than cast-iron.

Nevertheless they are utterly worthless for any of the purposes for which steel is used, and the common result of the costly experiments of the inventors who endeavor to make steel directly from English pig-iron, is to produce a material very much like them. They usually succeed perfectly in their effort partially to decarburize the pig iron. They take out, say one-half of

the carbon, and with it a considerable portion of the silicon, and *some* of the phosphorus, sulphur, and manganese; but to make a *perfect* steel they must take out *all* of these latter, and leave nothing but pure iron and carbon. Absolute perfection is not, of course, practically attainable in steel-making, but it is approximated in exactly the same degree, as the purification of the iron from every thing excepting the carbon is effected.

The most notable modern attempt to produce steel directly by the simple decarburization of English cast-iron was that of Mr. Bessemer. His first idea was to blow air through melted cast-iron, and thereby to oxidize the carbon, and then, when a sufficient degree of decarburization was effected, to stop the blowing. He supposed that when bythis means the proportion of carbon was reduced to about one and a half per cent. the result would be useful steel. He failed entirely in this; he never succeeded in producing merchantable steel from ordinary English cast-iron by this method.

The Bessemer process, as at present conducted, consists in first oxidizing simultaneously all or nearly all the carbon and silicon, and then adding to the decarburized iron a new dose of carbon, by means of a known quantity of spiegeleisen of known composition; thus reverting to the old Sheffield principle of first bringing the cast iron to the state of wrought or decarburized iron, and then adding carbon to convert it into steel.

It is commonly represented that the failure of the early attempts at direct steel-making by the Bessemer process arose simply from the difficulty of determining the right moment at which to stop the blow, and thereby to regulate the proportion of carbon; and that the whole advantage of the spiegeleisen is the means it affords of doing this. Dr. Percy says:—"In attempting to produce steel by the methods specified by Bessemer, it has hitherto been found very difficult, if not impracticable, *at least in this country*, to ascertain with certainty when decarburization has proceeded to the right extent, and when therefore the blast should be stopped. Accordingly the plan now adopted is to decarburize perfectly, or nearly so, and then add a given proportion of carbon in the state in which it exists in molten spiegeleisen, the precise composition of which should of course be known."* Neither in Dr. Percy's nor any other account of the Bessemer process do I find that the necessity of complete decarburization as a means of completely separating the silicon is fairly appreciated.

If merchantable steel could be made from English pig-iron by simply stopping the blow before complete decarburization, Mr. Bessemer would surely have produced some good steel in the course of his long and costly efforts which preceded the idea of introducing the spiegeleisen, for it must be remembered that the quantity of carbon required in steel extends over a very wide range—that steel may contain from 0.40 to 2.00 per cent. of carbon, and that steel with every degree of carburization within this wide range is in demand in the market at good prices, provided it be free from phosphorus, silicon, etc. Nothing is practically easier than to stop the blow at such a moment as shall insure a degree of carburization somewhere between this wide range; and there can be no doubt that in his early experiments, Mr. Bessemer, like other inventors of direct processes, made an abundance of iron that was duly carburized within the above-stated limits, although he failed to produce useful steel.

Dr. Percy's qualification, "at least in this country," is rather curious. He has probably learned that steel has been directly made in Sweden (though he does not mention it in his work) by the Bessemer process, and he seems to attribute this to the superior ability of the Swedish operators, enabling them "to ascertain with certainty when decarburization has proceeded to the right extent." I differ entirely from Dr. Percy in this conclusion, being convinced that Mr. George Brown, the manager of the Bessemer Department at the Atlas Works, Sheffield, who was the first to work the Bessemer process with commercial success, is better able (on account of his much greater experience and thorough knowledge of the work) than any of the Swedish manufacturers, to determine when any required degree of decarburization has been attained. It is not the superior skill of the Swedish operators that has enabled them to make steel directly by the Bessemer process; but the

* "Metallurgy," "Iron and Steel," p. 814. The italics are my own.

fact that they, like the Styrian workers, used a very superior charcoal-iron to start with; and that the blowing out of all the carbon was not absolutely necessary for the sufficient purification of this quality of iron.

II.—The greatest enemy to steel is phosphorus; one-tenth per cent. is sufficient to produce serious deterioration, and even to render the harder varieties of steel utterly worthless. As our common English pig-iron is made from clay ironstones, many of the nodules of which contain, as nuclei or otherwise, the remains of fishes and other animal matter, they are exceptionally rich in phosphorus; and thus all the difficulties of steel-making are greatly increased in this country. There are few results in connection with the progress of British industry of which we have better reason to be proud than our pre-eminence as steel-makers, in spite of the greatest natural disadvantages; and this is the more remarkable from the fact that so great a triumph has been gained by illiterate men who have achieved it by following out with a remarkably sound though unaided sagacity the strict method of true Baconian inductive investigation. Whenever I meet a formulating book-stuffed pedant, I love to tell him of the great unconsidered fact, that, while the learned men of the Middle Ages were muddling their intellects with worthless disputations, the artisans of that period were true inductive philosophers, and that the revival of science only commenced when the men of the universities adopted the method which had always been followed by the men of the workshop.

If the men of the universities have outstripped the men of the workshop in recent times, it is simply due to the fact that science has kept systematic record of its achievements, by means of which each worker has the full benefit of the labors of his predecessors and fellow-workers, and he is able to start from the point where these left off; whereas the workshop observers and experimentalists have worked with little or no systematic co-operation. If such co-operation only among one set of investigators has done so much, what may we not expect when it shall not only be extended to the other, but when both sections shall co-operate with each other? This technical and scientific co-operation is the great want of the present age. The artisan needs scientific education, and the professors of science have much to learn from the great mass of facts included in the practical experience of the workshops.

But I must not at present be carried further away into this tempting digression, but return to my main subject by anticipating an objection which will probably be made. The manufacture of puddled steel may be supposed to refute all I have said respecting the impracticability of producing steel directly from English pig iron. If steel fit for the manufacture of files, chisels, etc., could be made from ordinary English pig iron by this process, all my statements certainly would be refuted, for puddled steel is simply made by checking the oxidation and arresting it at such a point that some of the carbon in the pig iron shall remain unburnt.

The facts connected with the manufacture of puddled steel which bear upon the present subject are as follows:—First, puddled steel of merchantable quality cannot be made at all from common English pig iron; second, the manufacture of puddled steel has been much more successful on the Continent than in England; third, only mild steel and that of an inferior quality is made by this process from English iron.

Referring to the first fact, I may mention that there is a great deal of mystery, and there have been a great many failures and much waste of labor, fuel, and iron, in carrying out this process in England. In many forges where it has been tried it is now altogether abandoned, and where it is carried on with any degree of success there is usually much secrecy maintained. Now the mystery is not in the puddling, as the necessary modifications in the supply of cinder and the working of the damper are well understood, and have been sufficiently explained in the specifications of abandoned patents and otherwise. The secret part of this process is in the selection of the pig iron, or rather of the "blend" of pig iron, for it is found that a mixture of certain brands of pig iron is better than any single brand used alone.

My own experience in connection with this subject has been very interesting, and is, I think, worthy of record. When engaged as chemist in the works of Sir John Brown and Co., of Sheffield, I made care-

ful analyses of all the numerous brands of pig iron that are used for various purposes in these works. These I tabulated and kept continually before me in order to compare their composition with the special uses to which they were applied, and the properties which they or the material made from them exhibited. The manager of the iron department was a remarkable example of one of those self-taught unconscious Baconian philosophers, I have above alluded to. He has during many years been observing, experimenting, and generalizing his inductions, consisting of a code of original rules for the manufacture of iron suitable for various purposes. Like the man who had talked prose all his life without knowing it, he has been following strictly the injunction of the "Novum Organon" in discovering the best "blends" of pig iron for manufacturing respectively armor-plates, rails, boiler-plates, angle-irons, etc., etc.; and among his other mysteries were certain blends for making puddled steel. These he calls his "steel irons." He selected these, like all the others, without having, or pretending to have, any knowledge of their chemical composition.

By quite a different path, *i. e.*, upon purely theoretical chemical grounds, I had determined that certain brands among those I had analyzed were the best fitted for making puddled steel, and was anxious to verify my theory. To have asked directly for a revelation of the iron manager's secrets would have been unreasonable, and, therefore, I simply gave him a statement of the analyses of these particular brands all arranged together, and called them "steel irons," adding that for the best work I supposed that he mixed with them a proportion of a certain foreign brand. "Hush, don't talk so loud; I don't want these fellows to hear you. Who told you that I use these?" was the substance of Mr. Jevon's reply. My theoretical and his practical selection proved to be exactly the same in result. He had selected just those particular pigs which contained the smallest percentage of phosphorus, and which relatively to their carbon contained the smallest proportion of silicon.

But this was not all. I had just concluded a number of experiments made for the express purpose of determining the function of manganese in the manufacture of iron and steel, and had come to the conclusion that its usefulness depends upon its readily oxidizing, even before all the carbon is oxidized, and thereby affording a base with which the silica could unite and form a liquid and readily fusible silicate. Now this is just what is wanted in making puddled steel, and hence I suggested the addition of the highly manganiferous foreign ore. He had recently discovered that it did just what I expected, and supposed that his discovery was quite new. Such, however, was not the case, for this, like so many other trade mysteries, had been independently discovered by a number of other practical investigators.

The foreign manganiferous metal referred to is spiegeleisen. Dr. Percy says: "Spiegeleisen has been found admirably suited for the production of puddled steel of the best quality, and accordingly it is largely used for this purpose." Now spiegeleisen is remarkably free from those impurities which, as I have stated, cannot be removed from common English pig iron without also taking out the carbon. I find that the average proportion of silicon to carbon in English pigs is about three-fourths; in spiegeleisen it is below one-fourth; and that the average proportion of phosphorus in the samples of spiegeleisen which I have analyzed is less than one-twentieth of the quantity contained in our Cleveland pigs. Three, four, and five hundreths per cent. is the quantity I ordinarily find in good German or Swedish spiegeleisen. The sulphur seldom exceeds one-tenth per cent., and the large quantity of manganese materially assists in the removal of the silicon. It is, in fact, very similar to the Styrian cast-iron, which, as I have already said, does not present the English difficulty of making steel by the direct process. Both are charcoal irons, made from remarkably rich and pure ores. The manufacture of cast-iron from such ores, and steel from such cast-iron, is mere child's play compared with our native manufacture.

In reference to the second fact, that the manufacture of puddled steel has been carried out more successfully on the Continent than in England, I need only say that this confirms my statements, as the puddlers there are less skilful than ours, and their raw material is a vastly superior

charcoal iron, such as I have already described.

The third fact, viz., that only mild steel of inferior quality is made by this process, is further confirmation of what I have said respecting the necessity of removing the carbon from common pig-iron in order to purify it sufficiently to produce good steel; for even with all this skilful selection of the purest pigs and the mixing of spiegeleisen with them, it is found in this country impracticable to make puddled steel containing more than one-half per cent. carbon. Such steel is only fit for rails, tyres, for rubbish cutlery, and other purposes where a very soft steel, or rather steely iron, is used. If the puddling were stopped when the carbon was only reduced to about 1.75, or (say)1.5. per cent. (the quantity contained in the best hard cast-steel) the puddled steel would be utterly rotten, it would crush under the hammer whether hot or cold; the reason of this being that even with the best English pigs, the selected "steel irons," there would, with this amount of carbon, still remain a ruinous proportion of silicon, phosphorus, etc. It is necessary with all available advantages to bring down the carbon to within one-half per cent. in order to produce a workable material. Even then it is worth only about one-third of the price of good cast steel.

I might illustrate this subject still further by entering into the details of the chemistry of the Bessemer process and of Bessemer steel by the history of the nitrate of soda process, and of other attempts to manufacture steel directly from cast-iron; but I think the above is sufficient to expose the fundamental fallacy upon which all such attempts have been founded. I hope to have succeeded more particularly in demonstrating the very great error of those who, in their attempts to make such steel, have, like the friend of my correspondent whose letter opens this paper, deliberately chosen cinder pig or other inferior iron upon which to make their demonstrative experiments. This was the case with the Heaton Company. They worked for a long time at Langley Mill with one of the worst classes of pig iron they could have selected for their purpose. I pointed this out to them in a letter printed in the "Chemical News," of February 19, 1869. This effort, the most promising of any of the kind, on account of the action of the residual alkaline soda, was, through this serious mistake, never fairly tested. I witnessed some of their experiments, and analyzed and otherwise tested the results. There can be little doubt that with properly selected pigs a material similar to puddled or Bessemer steel may be made by this process, and by several others that have been tried and have failed; but with the common classes of English pig irons all such attempts to make steel directly by the partial oxidation of the carbon must of necessity fail, unless some entirely new, some hitherto utterly unknown method of removing the silicon, phosphorus, and sulphur of the pig iron is also used. In such a case the novelty, the invention, the triumph, would consist, not in the decarburization of the cast-iron, but in the separation of the other ingredients.

I therefore recommend all inventors who seek to simplify or otherwise improve the manufacture of steel to direct their attention first to the removal of phosphorus, next to the removal of silicon, thirdly to the removal of sulphur, and last and least of all to mere decarburization, for that is a problem of the utmost simplicity, and already sufficiently understood.

My next paper will be "On the Chemistry of the Bessemer Process," and will include some original observations, the results of which I believe to be of considerable value to the numerous manufacturers who are now erecting or working Bessemer plant.

AKRON, Ohio, is largely engaged in the manufacture of various kinds of pottery ware and fire brick. A good clay bank is worth more money to a manufacturer of those wares that a coal bank is to a coal dealer. The clay industry of Summit county exceeds a million of dollars annually, without taking into account the manufacture of ordinary building brick. The sewer pipe manufacturers sell an annual average of more than $350,000. The fire brick sales amount to nearly $100,000, and the other various forms of pottery amount to more than half a million of dollars. The clay for all these wares is found in Summit county.

THE Brier Hill, Ohio, furnaces are blowing out and will stop operations for the present.

GERMAN SMELTING WORKS.

From "The Mining Journal."

Nestling in the ravines of the Hartz, like the cotton-mills in the Lancashire valleys, are numerous smelting works. The frequent occurrence in the topographical terminology of blei, German for lead, and hutte, a smelting house, as Silberhutte, Frederickshutte, indicates the antiquity of the industry. Among those we visited, the works at Frederickshutte, between Zellerfeld and Goslar, were examined most in detail. And we the more readily select this for description, in that we there witnessed the working of a process for desilverizing lead, which, we were assured, is far in advance, both as regards the metal production and economy, of the Pattinson method, so universally adopted in England.

Although, as we have before intimated, there are serious objections against the Hanoverian system of working the mines and metal works directly by the State, yet there is this manifest gain, that each mine and works is able to secure a really skilful and scientific superintendence, which is more than can be said for many of our English mines. This arrangement results in a strong family likeness amongst all the mines and works, so that when one work has been examined, we find in the others precisely the same steady operations and the same stolid and enduring workmen. Each works seems to have been produced from exactly the same seed, and to differ only in the extent of its development, according to its locality and other conditions of growth. The general standard to which the ores are dressed is 75 per cent. Of this dressed ore, in the Zellerfeld Works, 66 per cent. is actually secured in metallic lead, while of the remaining 34 per cent., 13 represents sulphur, and the rest slags of various other matters present in the original ore, and loss. These amounts are by no means patent to a cursory inspection, as the matters with which the furnaces are charged are of so varied a nature, consisting not only of the picked and sieve ore, but of the impure fine ore from the jigging-tubs and buddles, containing a considerable amount of silicious matter, and of the various refuse matters from former operations, having very variable compositions.

The principle upon which the lead ores of the Hartz district are reduced is identical with the ordinary process for conducting a dry assay, and depends on the fact that iron has a greater affinity for sulphur than lead has; a sulphide of iron is, therefore, formed at the expense of the sulphur in the galena. The general form of furnace is a tall rectangular mass of masonry, of which the slightly hollowed hearth occupies only a small portion of about 3 ft. The hearth is gently inclined toward the front, to which place the melted matters flow, slag at the top and the metal underneath. A second and lower basin, communicating with the bottom of the slag hearth, receives the lead from time to time when the workman removes the plug. The blast is supplied by bellows worked by a water-wheel. The workman pride themselves greatly on the skill with which, by regulating the blast, they can control the formation of a sort of slag-pipe that forms around the blast in the furnace, exactly like the incrustation that covers up the channel of liquid slag flowing from an ordinary iron blast-furnace. This slag-pipe, formed by the cooling effect of the blast upon the molten mass in the immediate neighorhood of the tuyere is said to be of the greatest service in preventing the too energetic action of the blast on the ores at the tuyere end of the hearth.

The usual furnace charge at the Zellerfeld Works is in the following proportions. The amounts, as given by workmen at the smelting works have been supplemented by extracts from "Regnault's Chemistry":—Sulphide of lead, a mixture of hand-picked, sieve, and smiddim ore, 37 cwt.; litharge, derived from cupellation, 6 cwts.; slags of mixed nature, 43 cwts.; cast-iron, 5 cwts. This mixture produces 24 cwts. of metallic lead. The greater portion is deposited in the receiving basin, directly from the first fusion; but about one-eighth of the above quantity is derived from subsequent operations on the slags and matts, in manner to be presently described. The object of so large a proportion of slag in the charge is to retard fusion until desulphurization is pretty well advanced. Instead of the long

chimney-flue adopted in English smelting works, these furnaces are furnished with a series of chambers, in which the lead vapor is condensed. These are periodically emptied by means of iron doors. The contents of the receiving basin in front of the lead furnace, to which we have already referred, readily separates into two portions, the lower one consisting of metallic lead, and the upper one chiefly of sulphide of iron, with a strong percentage of lead. This matt is allowed to accumulate until there is a sufficient quantity to calcine. It is then mixed in heaps, with alternate layers of fuel, and a slow combustion is carried on for from 20 to 25 days, during which time the sulphur is driven off as sulphurous acid. When the heap has burnt out it is carefully hand-picked, and those portions not completely desulphurized are set aside to be added to the next heap, and put through the same process again, while that part of the heap which is thoroughly calcined is removed to a small furnace supplied with a good blast, where it is reduced in connection with slags and metallic iron. Here the same mixed product is obtained—metallic lead and a second matt. This matt is passed through the same roasting process, and the whole operation is repeated in the furnace until the fourth or fifth matt has become, through these successive concentrations, so rich in sulphide of copper as to be worth treatment for its extraction. In some of the Hartz works the lead is so rich in silver as to be cupelled at once. But in most cases the lead is desilverized by a process which was quite new to us, though we have since understood that the process has been tried by the Messrs. Neville & Co., at Llanelly. The lead, in ingots, is placed in a large cast-iron pot, similar to those used in the Pattinson process. When the lead is melted, and the refuse skimmed off, a quantity of melted zinc is added, equal to about 28 oz. to each ounce of silver, as shown by assay to be present in the lead. The alloy is kept in a melted state for two hours, and constantly stirred. The mass is then allowed to cool, and a thick scum forms on the surface. This scum is a mixture of zinc, lead, and silver, and after being removed to a furnace and exposed to a dull red heat for some time, to drive off the zinc, is cupelled in the ordinary way. The lead is further purified by having billets of green wood thrown in while the lead is in a liquid state. A considerable quantity of gas is generated, which gives a singular aspect to the pot of molten lead. The bubbles of gas arising and taking fire at the surface present the peculiar appearance of a blazing liquid. This was the process as we observed at Frederickshutte, but we were informed that at some works steam is driven into the melted lead, instead of adding green wood. The advantages of this over the English Pattinson process, are in cheapness, the better quality of lead, and in the higher state of concentration of the mother liquor to be cupelled. The Pattinson process does not profitably admit of concentration to more than 500 oz. to the ton, while in this process it usually reaches 1,000 oz. It seems this method was patented in England some years ago, under the name of Parke's process. It appears a matter of surprise that this plan has scarcely yet been adopted in this country. We understand that Dr. Percy intends to give a full description of this method of refining silver in the edition of his forthcoming new work on metallurgy. The advantage of this method in requiring fewer workmen is one that appeals even more strongly to the English smelter than to the German, though, on the other hand, zinc will be cheaper with them than with us.

The charges for the furnaces around Rammelsberg were given as follows :—21 cwt. of ground ore, 11 cwt. of silicious slag, 4 cwt. of lead slag, and 36 cwt. of charcoal. The blast is applied, and the reduced lead falls into the hollow of the hearth, while the slag is skimmed off by ladles. The amount of sulphur in these ores is so considerable that though they are roasted in heaps previous to being brought to the smelting-works, it is yet needful to add so much slag to prevent fusion of the ore until the chief part of the sulphur is driven off. North Germany raises 169,000 tons of lead ore annually, and manufactures 40,000 tons of metal. Of this the greater part is sold as pig-lead, but about 800 tons of it are sold in the form of sheet-lead. The produce of silver, chiefly from the ores of galena, is 148,689 lbs. troy in the year. The lead mining employs 15,784 hands, and the metallurgic refinement as many more.

THE MINERAL WEALTH OF INDIA.

The Calcutta "Englishman" remarks that India seems on the verge of losing that exclusively agricultural reputation for which she has hitherto been distinguished. The latent belief in her mineral treasures is now likely to become an active principle of Anglo-Indian life. In the Punjab there is salt enough to supply the whole Peninsula, if only it can be made available by cheap carriage. The Himalayas contain a land of silver—the Wuzeeri Roopah country; and although they have never been properly prospected indications have been found here and there, which, if worth anything at all, would prove that they are not inferior in mineral wealth to any mountain range in the world. To say nothing of graphite at Almorah, and iron in Kumaon, the Hon. Ashley Eden thus speaks of the peculiarity of the valley of Paro, in Bhootan:—

"The soil about Paro is charged with iron to a singular extent; by placing a magnet down on the ground anywhere in the valley it was at once covered with a kind of metallic iron dust; by collecting a heap of sand, and working it with a magnet, a very large percentage of iron was separated from the sand. The whole hill sides above were yellow, and were apparently full of iron. There is an iron mine about two days' journey from Paro, and the Bhooteas declared that they obtained lead from the same mine, but in small quantities. It is certain they do obtain lead to a small extent in their country."

When we turn from the Himalayas to Central India we come upon a mineral district, which, commencing within 100 miles of the capital, stretches for an unknown distance toward Bombay. To the south, the discovery of coal at Chanda may be said to extend to the valley of the Godavery; while to the west, the Nerbudda Coal and Iron Company have opened workings at Morpani, close to the eastern borders of Bhopal. Besides this vast field, the trans-Megna districts produce coal of an excellent description. Seams of from 4 to 6 feet in thickness have been worked at Chena and Lacaday, in the Khasia and Jynteeah hills; and on the banks of the Dehing, in upper Assam, there are numerous out-crops of perhaps the best coal in India. In the valleys on the eastern side of Central India are found gold and a variety of precious stones. Far away to the west, in Bundelkund, the Rajah of Punnah has a few diamond mines, and the plateau of Rewah is known to abound in the most valuable ores; there are gold and gems in the streams, copper in Manbhoom, and iron almost everywhere. At Mahemmedpore, near Soory, within a few miles of the Cynthia Station of the East Indian Railway, rich, though somewhat intractable, iron ore is found, and we believe that it is no secret that at Jamalpore a valuable paint has been made from ironide of iron, sent down by the engineers employed on the Allahabad and Jubbulpore line. As for coal, following what seems to be almost a law, wherever iron has been found, there also has coal been discovered. Perhaps a better estimate will be formed of the extent of the coal deposits of Central India if we refer to the map. Coal there has been found over an area of at least five degrees of longitude in breadth, by four degrees of latitude in width—that is, from Midnapore to Mopani, east and west, and from Kurkurbaree to Chanda, north and south. Here, then, in the very heart of India, we have an immense "black country," a country of hills and vales, and lofty plateaus, where cotton grows luxuriantly, and where immense plains produce fabulous quantities of grain.

The prospect held out to India is, shortly, that a cotton-growing country shall also be a cotton-manufacturing country. At places like Khandalla, on the Western Ghauts, Europeans can not only live, but flourish in a healthy mountain climate, and here on the margin of the great cotton districts of Berar, Chanda coal could be put down at a rate which would beat English mineral fuel out of the field. Hitherto, again, the iron ores of India have been neglected, because of the difficulty in procuring good fluxes. But with open lines of railway it only requires the discovery of a good bed of lime to find the ore travelling in the rough state to points where it can be usefully worked. The necessities of a great railway system will speedily make it as imperative to use Indian iron as it is now to use Indian coal;

and when that day comes the Central Provinces, which have a population devoid of many prejudices and ready for the work, will enter on a new and unexampled career of prosperity, and furnish the Government with new sources of strength and new guarantees of the stability of British rule.

THE STRASBOURG CLOCK.

From "The Mechanics' Magazine."

The great clock at Strasbourg is one of the wonders of the world about which travellers are often apt to romance a little, making it out more wonderful than it really is. But for all this, it is an extraordinary piece of mechanism, and its performances entitle it to rank high in the records of horology. All those who pass through Cheapside witness hourly—nay, four times an hour—with some degree of wonderment the activity of a set of figures which strike the chimes and the hours outside the house of one of our most enterprising citizens. But these are wonderfully simple operations as compared with those of the celebrated Strasbourg clock, of which the good citizens are justly proud. Before detailing these performances and describing the clock, it may be as well to refer to the history of this ingenious piece of mechanism. The clock stands in the Cathedral, its origin dating as far back as 1352, in which year it was put up under the patronage of Berthold de Buchek, then Bishop of Strasbourg. Of the artist's name nothing appears to be known; he must, however, have been considered a prince among clockmakers in his day, for the clock appears to have been a highly successful work of art for the period. It was divided into three parts, the lower portion exhibiting a universal calendar. In the middle part was an astrolabe, and in the upper division were the figures of three kings and the Virgin carved in wood. At the striking of each hour the three kings bowed to the Virgin, whilst a carillon carolled a cheerful tune, and a cock crowed and clapped his wings. In course of time, however, this clock got out of order, and in 1547 its repair was committed to the charge of Dr. Michael Herr, Chretei Herlin, and Nicholas Prugnor, three mathmeticians of repute. They died before their work was finished; but it was taken up by Conrad Dasypodius, a pupil of Herlin, and who completed his task in four years. The clock went well until the year of the great Revolution, when it struck for the last time.

Nearly fifty years passed, during which time the great clock gradually fell into a very dilapidated state. It was then resolved once more to restore it to its former working condition; but this was found to be impossible, as the works were eaten up with rust and verdigris. At length one Schwilgue, an artist and mathematician of Strasbourg, offered to repair, modify, and reinstate the clock; which task, it is recorded, he commenced on June 24, 1836, and finished in four years from that time. It is stated that Schwilgue received an order to construct a similar clock for a cantonal capital in Switzerland; but his townsmen, jealous of the horological fame of Strasbourg, put out his eyes, and thus prevented him fulfilling the order. We have no authority for this statement, and therefore can only consider it in the light of one of the traveller's tales to which we have already alluded.

The mechanism of the new clock was placed by Schwilgue in the old casing, the number of the figures having been increased, and their appearance being improved by jointed limbs. The quarter chimes are struck by figures representing the four ages of man, which move in a circle around a skeleton mower. The hour bell is struck by a Genius, a figure of an angel at the same moment turning an hour glass, through the narrow neck of which the sand is kept perpetually running year after year. Every day at noon a procession of the twelve apostles takes place around a figure of the Saviour. Each one in passing inclines towards the central figure, which, when the circuit has been made, extends its hands as in the act of blessing. During the procession a cock flutters his wings, opens his beak, and crows three times. The clock shows the month, and the day of the month, the sign of the Zodiac, the Dominical letter, the sidereal time, the Copernican planetary system,

and the procession of the equinoxes. Its mechanism is so perfectly elaborated that it marks the twenty-ninth day of February in every leap-year. With this perfection of detail, no wonder that the citizens of Strasbourg are proud of their Cathedral clock, and no wonder either that travellers are neither slow to visit it nor to enlarge its performances to an extent somewhat beyond its real capability.

THE PRESERVATION AND PURITY OF IRON.

From "The Builder."

But few subjects connected with the craft of the builder, the work of the mechanical engineer, or the labor of any workman who is concerned in the manufacture or the preservation of iron-work, have more importance than the question, "What is rust?"

"Why, every one knows what rust is," many a reader may reply. "It is impossible to read any work touching on this subject, without becoming aware that rust and oxide of iron are used as equivalent terms."

Such, no doubt, is the general view; but the use of language, however, general, is by no means a proof of the accuracy of the statement (the truth of which is taken for granted), that the destructive action which we call rusting is nothing else than the oxidation of iron by exposure to damp and to the atmospheric air; or, in other words, that rust *is* the oxide of iron.

It is obvious at a glance that this is not a mere curious question of speculative chemistry. It is not a pedantic quarrel about words. Rust, whatever may be the etymological affinity of the word written in Latin, *rubigo*, is good, plain, vernacular English. We all know what the word means, to a certain extent; and we all of us have more or less suffered from the liability of iron-work to be deteriorated by its attack.

But the main importance of knowing what rust actually and chemically is, is not literary. It is eminently practical; for thus alone can we arrive at the answer to the yet more urgently practical question, "How shall we preserve iron from rust?" If we mistake the nature of the evil, we shall not be unlikely to mistake the nature of the remedy.

Before entering into the investigation of any chemical hypothesis on the subject, let us call attention to the result of an experiment made recently by an eminent chemist, with a view to determine the nature of the action which generates rust.

Two pieces of soft iron, of equal dimensions, were filed up smooth and bright. A solution of bicarbonate of soda was placed in a test tube. A portion of the same bicarbonate was placed in a crucible, and subjected to a heat which rendered it caustic, and a solution of this caustic soda was placed in a second test-tube. One of the pieces of iron was placed in each tube. The first of these, that placed in the ordinary solution, instantly began to rust, and continued to evince the active progress of that destructive process. The latter remained quite bright.

It was left in the solution for about six months, towards the close of which period it began to show symptoms of chemical action, and finally rusted like the companion specimen.

The cause of the behavior of the iron in each instance is made perfectly intelligible on the theory that the red, destructive rust is not, as ordinarily imagined, an oxide of iron, but a carbonate of the sesqui-oxide ($Fe_2\ O_3\ C.O_2$). On this view the presence of carbonic acid is necessary for the production of rust. The bicarbonate solution ($Na\ O.\ 2\ C.O_2$), was readily decomposed, and set at liberty the carbonic acid and oxygen to attack the iron, which, accordingly, immediately began to rust. But when this equivalent was driven off by heat, the iron placed in the caustic solution was not in a position to attract carbonic acid, and therefore did not rust. Its freedom from destructive action continued until the solution, being left in an unstoppered tube, had attracted enough carbonic acid from the atmosphere to lose its causticity. The moment that enough carbonic acid had been absorbed by the solution for it to *spare* some for the iron, rusting commenced. The experiment is extremely elegant, and it is diffi-

cult to resist the inference which is drawn from its results.

The view that the corrosive rust of iron is, like that of copper, a carbonate, accounts very clearly for the destructive action which takes place when iron is set into stone-work, or in any way wedged into buildings surrounded by mortar. The chemical change which takes place in the drying and hardening of mortar is, after the first short period of setting, extremely protracted. During the whole of this slow process carbonic acid is at liberty to attack the inclosed iron, and hence arises that thickening sort of rust which, almost as if with the growth of vegetation itself, slowly and irresistibly acts as a destructive wedge.

Iron may, however, be used in the interior of buildings with perfect safety, if it is protected from the access of carbonic acid. A remarkable instance of this occurred, as a piece of practical experience, on the demolition of the Wriothesley-street Bridge, on the London and Birmingham Extension Railway. This bridge was erected in 1835. Like the Hamstead-road and the Park-street bridges, it consisted of brick abutments, pilasters, and piers, supporting cast-iron girders, between which were brick segmental arches, *set in Roman cement.* On the pulling down of this bridge for the extension of the Euston station, it was found extremely difficult to separate the brick-work from the girders. It was as easy, or more so, to break the bricks themselves. But when the separation was effected, it was found that this unusual adhesion was caused by the entire *absence* of rust. The blue scale remained uninjured on the face of the metal, —red incrustation there was none. This blue scale, no doubt, *is* the oxide of iron, which forms, as in the case of other oxides, a coating of a protective character. The confusion of this harmless oxide with the destructive carbonate is an error of no trivial importance ; and its detection bids fair to lead to the reconsideration of the entire subject of the protection of iron-work from rust.

Closely connected with the question of the action of carbonic acid on iron is the investigation of the facts, which at present seem to be so anomalous, observed as to the intimate union of carbon and of iron in cast-iron and in steel. Why the elimination of a small proportion of carbon from the metal (or alloy) should be accompanied by such an increase of power of resistance to tensile strain, and why the reintroduction of a yet smaller proportion should be attended by so much more considerable an increase, is a mystery of economic metallurgy which it is of extreme importance to solve. The entire question of the behavior of steel is one requiring much elucidation.

That steel, under certain conditions, evinces a metallic tenacity, and power of resisting fracture, of the very highest degree, is evident from the effect of impact on steel shell, when fired at armor plate. The action of that sudden and terrible blow, which shatters the case-hardened iron shot, is like that of the blacksmith's hammer on a bar of cold iron, dexterously manipulated on the anvil. We know that iron can thus be hammered till it is hot. The steel shell, in like manner, is heated until it actually explodes its contents. At the same time the head of the projectile is hammered out of shape ; but no fracture takes place. The tremendous force of the blow seems to be converted into thermometric, or rather pyrometric heat ; and the steel, thus heated, forges as beneath the steam hammer. The property of steel shell was discovered by accident, a fuse having been picked up on the practice ground when there had been no blind shell fired ; but, thus discovered, it has been made use of for the purpose of exactly timing the explosion of the projectile.

On the other hand, we have the fact that a steel armor plate, prepared with the utmost care for the purpose of experiment, tempered in oil and produced with the full expectation that it would evince a power of resistance never previously developed, was fractured, and speedily put *hors de combat*, by the comparatively trifling assault of a 68-pound shot. This difference in the behavior of steel as hammer and as anvil, as projectile and as armor plate, is, as yet, entirely unexplained.

The interest of these inquiries is not merely philosophical. It is practical in the highest degree. So long as we are aware of the existence of facts, quite unexplained, but in which the most (apparently) inadequate causes produce the most extraordinary results, we are in the position of people who are on the brink of a discovery. How brilliant that discovery may

be, we cannot tell. We are on the scent of a treasure trove, but we can only guess at the size of the crock of gold. Mankind has made use of iron for at least four thousand years, for fragments of iron tools have been found in the Great Pyramid, left by the original builders. How long was it before iron was turned into steel? And, even at the present day, while producing iron by millions of tons, and paving our railways with steel, we are discussing the chemical action which produces rust, and we are entirely ignorant of the intimate cause of the differences between iron and steel, so far as regards the effect of the dose of carbon.

It is stated by Sir W. Armstrong that both in the Elswick and the Woolwich guns whenever failure takes place, it almost invariably originates in the part which is made of steel. The steel tube is the part that cracks first. Steel vent pieces, which were first employed, were fractured with alarming frequency; but since iron ones have been substituted, fractures have been rare. It is argued from these facts that the vibratory action attending concussion is more danger us to steel than to iron.

The peculiarity of the case consists in the apparently contradictory behavior of steel when used as a projectile, as a gun, and as a target. It is quite true that, in all manufactures of iron, the two opposite qualities of hardness and of toughness have to be considered. We are not so ignorant of the practical part of this branch of metallurgy as to be unaware of modes of tempering, and of annealing, and generally of producing a metal suitable to the purpose in view. But what we *do not* understand is the law which regulates the existence of these properties. Our knowledge on the subject is almost entirely empirical. The tensile strength of wrought iron is considered to be due in great measure to the removal of the 4 or 5 per cent. of carbon which is contained in cast-iron. The formation of laminated fibre by hammering, no doubt, has much to do with the change; but the chemical difference is important. Yet when iron is made into steel, the tensile strength of the latter is increased by the addition of carbon up to the proportion of some 1¼ per cent. With this very increase of tensile strength, however, contrary to all analogy, we find an increase of brittleness to coincide. For resistance to impact, it is considered that steel cannot contain too little carbon. That hardness and brittleness should increase or diminish together is not matter for surprise; but analogy would lead us to expect a different result to accompany the increase of tensile strength.

There is no doubt whatever that the great foe to the excellence of iron is impurity, especially the presence of sulphur. Our enormous production, and the commercial rivalry which has proven so strong a temptation to the manufacturer to study cheap modes of production, irrespective of their influence or quality, has deteriorated our iron to a lamentable extent. English axes are said to be useless in the forests of America, or against the iron-barked trees of Australia. The difficulty of producing, from the present wrought iron of commerce, anything approaching the excellence of the old English forged work, has been illustrated, within the past few months, by the high praise given, by very competent judges, to some specimens of smiths' work to which prizes were awarded by the Society of Arts the other day. If these prize specimens be compared, not only with the Hampton Court gates, forged in 1695 by Huntington Shaw, and preserved at South Kensington, but with such samples of neglected and unknown old English work as may now be seen in the course of rapid decay before an old house in the main street of Rochester, we cannot fail to deplore a sad decadence in the art; the fault, no doubt, as well of the iron-master as of the smith.

It would probably be impossible for any English smith now to produce such work as some of the later specimens of articulated armor in the Tower of London. On the other hand, where, for special purposes, special attention has been given to the manufacture of the iron, the result is satisfactory. We question whether either Toledo rapiers or Damascus sabres would stand uninjured, taking them one with another, the rude tests to which Mr. Wilkinson, of Pall-mall, subjects his best swords. It is true, that of these carefully made blades, we have seen three out of four damaged in the test. But the one which passes is a weapon to which a man may safely trust. If any corslet now worn in European warfare resists its thrust, it is the fault, not of the blade, but of the arm that wields it. In preparing iron for spe-

cial purposes, the chemical character of the water used in the factory appears to be very important. It was an old by-word in the steel trade that a good sword could not be made at Sheffield, nor a good knife at Birmingham, the sword being the boast of the latter town, and the knife of the former.

The practical upshot of these considerations ought to be, the concentration on the subject of the chemical properties of iron and carbon in combination, of the same kind of clear, patient, proposed attention as that which has thrown so much light, within the past few months, on the question of the propagation of disease by germs floating in the air. An immense amount of empiric inquiry is going on upon the subject. Great practical results have been attained. We need not particularize any of those processes as to which no small amount of controversy has recently raged. We are not undervaluing the labors of such men as Whitworth, Brown, Siemens, or others. Still, while the action of carbon in its relation to iron is so apparently capricious and contradictory, and while the destructive effect of carbonic acid, and the actual nature of corrosive rust, have been hitherto almost entirely unsuspected, we cannot doubt that a great reward, in fame at least, if not in gold, will atten the success of that scientific investigator who shall unveil the true law of the relation which subsists between the material which forms the hardest and the most precious of gems, and the mineral which, all things considered, may be pronounced the most valuable of metals. The Victoria cross of science awaits the discoverer of the law of the combination of carbon with iron. The fact that the presence of phosphorus produces "shortness" or brittleness in iron when cold, while that of sulphur has the same effect at a red heat, is another of those anomalous, and apparently capricious differences which chemistry has detected, but not explained.

Very closely connected with this part of the subject is the extremely important question of the influence of mineral or of vegetable fuel on the reduction of iron ore. So far from this being a mere matter of chemical curiosity, it is one which is most intimately connected with our national prosperity. It is well known that iron was originally smelted in England by wood, and that, under these circumstances, beds of ironstone, which are now entirely neglected, in consequence of their distance from the great coal basins, were advantageously worked. In the present state of the country, of course no fuel can be obtained except coal. In 1866, it is estimated by the Mining Record Office, 9,665,000 tons of iron ore were raised, and 4,530,000 tons of iron were produced, in the United Kingdom. The quantity of coal consumed in the 613 blast furnaces which smelted this total quantity of pig iron is not stated. The total quantity of coal raised in the year 1866 is set down as upwards of 101,500,000 tons. The iron made in England at present, or, at least, in 1866, was very nearly half the total make of the world, which is estimated for the preceding year, 1865, at 9,500,000 tons. We shall probably be under the mark in setting down 15,000,000 of tons of coals as consumed in our smelting furnaces. The average value of English coal, at the pit's mouth, is taken by the Mining Record Office at 5s. per ton, which would give something like 15s. for fuel for smelting a ton of coal.

In Russia charcoal is still almost exclusively used for smelting; and as to the superior quality of the iron thus produced there is no question. Nor as to the mere element of the cost price of production is the difference so much in favor of the inferior quality of metal as to lead us to entertain any very great confidence as to the permanent position which our ironmasters will occupy in Europe. From recent and very carefully collected information as to Russian iron-works, we find that iron is now produced by the consumption of 110 tons of charcoal to 100 tons of iron made. The lowest price of birch charcoal in Russia is 6s. 6d. per ton; 8s. 2d. per ton is considered a cheap purchase; and 14s. 9d. per ton, and even more, is paid in some establishments. As this variation in price, however, is almost all due to the expense of land-carriage, there can be no doubt that the service of the great iron-works by light railways, which can be laid and relaid year year after to the portions of the forest from which the supply is taken (on the principle of allowing from sixty to eighty years for the regrowth of the timber), will keep down the cost of charcoal for smelting, something below 10s. per ton of iron.

We have not space to exhaust this important subject at present. One thing seems to us to be clear, and that is, that unless the attention of our practical and scientific chemists is turned to the purification of iron smelted by mineral fuel, to the elimination of sulphur and other impurities, and to the elucidation of the complete scientific theory of the relations existing between iron and carbon, the time cannot be far distant when our blast-furnaces will be blown out one by one; and when the excellent charcoal iron which Russia can produce in any quantity, and at moderate prices, will replace Scottish, Welsh, and English metal in the market.

WROUGHT IRON AND STEEL—THE FLUO-TITANIC PROCESS.

In the April number of this Magazine is an article on the production of wrought iron and steel by the Fluo-titanic process, invented by Mr. James Henderson of this city.

At that time the experimental operations had been conducted only in the laboratory. Since then experiments have been made on a large scale at Messrs. Park Brothers and Co's works in Pittsburgh, in puddling furnaces, but without puddling, or the labor of stirring the iron during conversion; the only labor was that of "balling up" the wrought iron, and removing it from the furnace after the conversion was completed. The results obtained then, and also since, with red hematites at other works leave no doubt that it will produce iron for castings much stronger than any heretofore produced, or steel of any required quality, or pure wrought iron.

The mode of treatment in the above-named establishment was, by mixing the titaniferous iron ore and the fluorspar both in a powdered state, and then charging them upon the sole of the furnace. Gray pig-iron was then charged upon them, and when melted, was allowed to remain without stirring or puddling; as soon as the pig-iron melted, reactions began between the fluorspar and titaniferous iron ore and the silicon, phosphorus, sulphur, and carbon contained in the pig-iron.

To ascertain exactly the conditions upon which the changes are made in the cast iron, whilst under treatment, samples were taken from the bath of liquid iron at intervals whilst under treatment. The analysis of the first sample taken from the bath shows that the operation of the new process is entirely different to any other process, inasmuch as the silicon is entirely removed at the early stages of the process, and, with the silicon, phophorus is also taken from the iron, and the carbon is changed from the graphitic to the combined form.

The analysis of the first sample has been made by Mr. W. M. Habirshaw, analytical chemist, of 36 New street, in this city, and is annexed; analyses of Sanderson's and Krupp's cast steel, taken from Percy's Metallurgy, are also given for comparison.

Henderson's Refined Cast Iron.	Sanderson's Cast Steel.	Krupp's do.
Comb'd carbon..2.7144	not deter. ..	1.18
Graphite.....traces	....	....
Silicon.....0.0046	0 24 ..	0.33
Phosphorus 0.0349	0.02 ..	0.02

The other samples, taken at later intervals, have not been analyzed, as the analysis of the first sample made it evident that the later ones differed only in respect of the less amounts of combined carbon and phosphorus they contained. This has been confirmed by treatment of them as steel, it having been found that they possess the properties of steel, forging well, and tempering and hardening according to the various degrees of carbon contained in them. At the end of the operation the charge became wrought iron, by the removal of *all* the carbon. This iron forges, welds, and is neither cold short nor hot short. It was tested at the Fort Pitt Iron Works, in Pittsburgh, for tensile strength and elongation, as follows:

Specimen No. 1.—Short, for tensile strength, turned down from 1¼ in. sq. to dia. 63″, gave tensile strength of 68.952 lbs. per sq. in.

Specimen No. 2.—Long, elongated from 9″.4 to 11″.24 before breaking. The diameter of this specimen was reduced from .635″ to .452″.

Upon comparison of the refined cast

iron with Sanderson's and Krupp's cast steel, it will be evident to the practical metallurgist that every particle of the phosphorus in the refined cast iron will be removed during the subsequent oxidation of the required carbon, to form steel, and the working the ingots into marketable shape. No analysis of sulphur is given in this case, as the pig-iron used is known to contain but traces of it.

Heretofore, all processes have failed to remove the silicon entirely from the cast iron. And, as the sulphur and phosphorus cannot be removed until the silicon is acted upon, and the other processes fail to thoroughly remove the silicon, it has never been economically practicable to make superior steel and wrought iron, except by using pig-iron free from sulphur and phosphorus, and containing very little silicon. This has been owing to the fact that but *one* agent, oxygen, has been used. This agent has as great an affinity for carbon as for the other elements in the iron, consequently it has been necessary to remove *all* of the carbon, and form wrought iron in order to remove the other impurities. This defect in the old processes is entirely remedied in the new process, which consists in using *two* agents, viz., fluorine and oxygen, one of which—the fluorine—having greater affinity for silicon, and acting more energetically upon it than oxygen acts upon carbon, removes *all* of the silicon from the iron before the oxygen has time to combine with the carbon.

In the earlier stages of the new process, there is no waste of iron by scorification, as the silicon and phosphorus pass off in the form of vapor, and the only loss of weight attending the operation at this period is the weight of the silicon and phosphorus. Experiments made with the new process in crucibles, to produce steel and wrought iron (at temperatures 1,000 deg. higher than in the puddling furnace used for the larger experiments), have yielded considerably greater weight of wrought iron than the weight of the pig-iron used. These gains are due to the reduction of the iron in the oxide to the metallic state, and its incorporation with the rest of the metal.

There is no doubt that with a properly constructed reverberatory furnace in which a heat of 3,800 deg. can be kept, steel and wrought iron may be produced cheaper and better by the new process than by any other process in use.

Interesting experiments have been made with fluorspar and hematites for refining pig-iron, and will be made the subject of another article. H.

TESTS OF METALLIC BRIDGES.

Translated from "Revue Industrielle."

There has been hitherto no definite and settled official rule for testing metallic bridges on common roads. Sometimes the old rule is adopted of submitting the bridge to a uniformly distributed load of 400 kil. to the square metre.

A late circular contains tests well defined, as follows:

(1.) Metallic trusses should give passage to every vehicle authorized by the regulation of August 10, 1852; that is, to vehicles drawn by not more than 5 horses if they have two wheels, and by not more than 8 if they have four wheels; 11 tons load is allowed for two-wheel wagons and 16 tons for four-wheel wagons.

(2.) The dimensions of the parts are calculated so that the work of the metal per square millimetre under the maximum load is limited to 1 kil. for cast-iron working by tension; to 5 kil. for cast-iron working by compression; to 6 kil. for wrought or plate-iron, both for tension and compression.

Higher figures are permitted for large bridges, when justified by quality of metal, form, and disposition of pieces.

(3.) Each metallic bridge is subjected to the following tests: The first, by load uniformly distributed, is made by an additional load of 400 kil. to the square metre of floor, footway included. This load should remain for at least eight hours, and in every case until depression has ceased.

The second proof is for rolling road, and is made with wagons of two or four wheels, with maximum load, teams attached and walking. These are to move close, in as many files as the carriage-way

will allow. All should then stand on the floor for half an hour.

These regulations, made because of late accidents, will make the construction of metallic bridges more onerous than hitherto, especially for small structures. For large works above 20 metres long, there will be no difference.

A VISIT TO THE BESSEMER WORKS AT TROY.

At the late meeting of the American Association for the Advancement of Science, the members, by special invitation, visited the Bessemer Works of John G. Griswold & Co., a short distance below the city. The following excellent description of the process exhibited at the time was written by R. W. Raymond, Esq., U. S. Commissioner of Mining, for the columns of the "Evening Post":

There is a good deal of nonsense talked about the Bessemer process. Its product is frequently compared with cement or blister steel, and with cast steel, whereas it is neither chemically nor physically steel at all, but a very pure, homogeneous, somewhat highly carbonized wrought iron. This fact was admirably brought out in the paper of Lieutenant Dutton, read before the Associat on, and summed up in the words that the Bessemer, or pneumatic process, is a method of making cast wrought-iron. It is to be compared, therefore, with the puddling process, from which it does not essentially differ in chemical reactions, though the two are as unlike in mechanical means as could well be conceived. In puddling furnaces the oxidation and removal of the impurities of the pig-iron are effected by a reverberatory flame, accompanied by constant stirring of the charge. The great trouble is, that as the carbon burns out of the cast-iron and it approaches the condition of wrought-iron, the fluidity of the charge rapidly decreases, since the melting point of wrought-iron is considerably higher than pig—too high, in fact, for the temperature of the puddling process. Consequently, the iron coagulates and segregates in granules and lumps, like "butter out of the buttermilk in a churn," as Dutton well says. The spongy masses which finally result cannot possibly be as homogeneous as fluid, and even after passing through the squeezers, to express the enclosed impurities, may still contain portions of slag, besides which their consolidation by pressure into workable shapes cannot be so complete as that effected by a cast.

The Bessemer process effects both the mechanical stirring and the chemical purification (oxidation of carbon, silicon, etc.), by the agency of a powerful blast of air passing through numerous small perforations in the bottom of the converter; and this blast, at the same time, maintains throughout the process an enormous temperature, rising sometimes to 5,000 deg. Fahrenheit, by which an extreme fluidity of the charge is secured at every stage. The product, therefore, is directly cast into moulds, and requires no further purification.

The use of ferro-manganese, or spiegeleisen, at the conclusion of the heat, is what has led to the popular notion that the product of the pneumatic process is steel. The spiegeleisen does, indeed, reintroduce a small amount of carbon into the almost entirely decarbonized iron of the fluid charge, but this amount is far too small (at the Troy works only about one-fifth of one per cent.) to entitle the result to the name of steel.

QUALITY OF THE BESSEMER METAL.

There is little significance in names, however. The great point is, that Bessemer metal is better adapted than steel to resist many kinds of strain. This is especially true of railway strains, which true steel would but poorly resist. The recent absurd dictum of the "Tribune," that the Bessemer product is a failure, because it will not make good tools, shows how dogmatic is ignorance. If it were fit for tools, it would be the worst possible material for rails. If the Bessemer metal is called steel, it must be described as a very soft variety, containing but one quarter of one per cent. of carbon.

HOW THE WORK IS DONE.

But I set out to give you rather a description of the works than a discussion of the method. A large party of us availed

ourselves, the other day, of the cordial invitation of Mr A. L. Holley, the manager of the Bessemer works of John A. Griswold & Co., to witness a Bessemer "heat." As we entered the converting-room, 110 by 90 feet in size, with a lofty roof, the workmen were engaged in hoisting out of the moulds the glowing ingots from a previous heat, and depositing them on the sandy floor to cool, or loading them upon a railway truck for removal. The lifting was performed by cranes, which seemed to operate without direction, and, with almost superhuman intelligence, now descending and now rising or turning, as the handling of the 1,400 pound ingots required. Soon we noticed at the further end of the room an elevated platform, with a railing, behind which was a row of brake-wheels like those on a railroad car. Here stood several workmen, their hands upon the wheels, and the vigilant eyes of each upon the distant crane, which it was his business to control and guide. Thus, with a touch of the hand, the power of the hydraulic machinery was communicated to the lift. The pressure on the water used in moving the seven lifts and cranes and the two huge converters, is 300 lbs. per square inch. It is not too much to say, that without the aid of hydraulic machinery, the Bessemer process would be economically impossible.

THE CONVERTERS.

Our attention was at once attracted by the two five-ton converters. It is difficult to describe these so as to give a clear notion to one who has not seen them, but I will make a desperate attempt. Imagine a huge iron vessel, 14½ ft. high and 9 ft. in diameter externally, cylindrical in form at the middle, and contracting in hemispherical curves above and below. The lower hemisphere is truncated, giving a flat bottom, say 5 or 6 ft. in diameter, of which more presently. The upper hemisphere terminates in a large neck inclined sidewise, so that a flame issuing under pressure from the mouth would not be vertical, but obliquely directed; and, when the converter is in an upright position, the flames will enter the chimney, guarded by a hood. The whole vessel has a rude resemblance to a pear. It is supported by heavy trunnions on each side of the centre, and revolved upon these by hydraulic power. A boy at one of the wheels on the remote platform before mentioned, swings the ponderous mass about its axis with ease, performing, by the aid of machinery, the work of 50 men.

We may consider the converter as a huge iron bottle, with its neck awry, lined with a foot of refractory silicious material, and rotating at will upon an axis at right angles with its length. It is in this bottle that the melted pig-iron is to be exposed to a fierce agitation and oxidation by means of a blast of air, and thus, the carbon and silicon being burned out of it, converted into malleable iron. Evidently the only place where the blast can be introduced is through the trunnions, since these are the only points in contact with the solid supports. Accordingly, the trunnion is hollow, and a passage from it runs down the outside, looking like a strong rib in the iron surface, to the bottom, where it communicates with the tuyeres. The bottom of the converter is movable (an improvement introduced to facilitate repairs by Mr. Holley), and when taken out looks like a great plug of fire brick, 2 ft. high, resting upon a cast-iron disk. The tuyeres, or nozzles for the blast, are imbedded vertically in the lining, and present 10 groups, each containing a dozen three-eighths inch holes. The aggregate area of these openings is equal to that of a single tuyere 4.1 in. in diameter, but the thorough agitation produced by dividing the blast secures much greater useful effect. The pressure of the blast is 25 lbs. per sq. in. "This mechanical action," says Mr. Holley, "the numerous and violent air-blasts as a means of promoting the chemical reaction, is the essence of the Bessemer process."

When we arrived, one of the great converters was turned on its side, and we could see into its red throat. It was cooling down a little, preparatory to the removal of the burned-out bottom and the insertion of a new one. The other was moderately spouting fire, undergoing the reverse process of heating up, preparatory to a blast. In a few minutes the interior was hot enough, and the unwieldy monster, turning its mouth downward, vomited out the glowing coals which it had been digesting. Then it turned upon its side, and the end of a trough was brought opposite its fiery lips. This trough we could trace back, up a steep incline to the half distinguished breast of a cupola furnace

on the floor above. An instant more, and a white stream of molten iron comes leaping down with coruscating showers of starry sparks, and plunging into the mouth of the converter. (The position of the vessel at this time prevents the charge from running into the tuyeres before the blast begins. Afterwards the pressure of the air itself keeps the passage clear.)

INTENSE HEAT AND LIGHT OF THE BLAST.

Then the blast was let on, and the converter swung back to a vertical position. A tongue of white flame came roaring out of the mouth, dazzling our unaccustomed eyes. But neither the brilliancy nor the temperature of the flames was as great at first as they became shortly after. The silicon of the pig oxidizes first, without very intense flame; but as the graphite, and especially the combined carbon, begin to burn also, the heat rises to some 5,000 deg. Fahr., and the light is so brilliant as to cast shadows across full sunshine. A professor in our party had brought a spectroscope, through which we examined the flame with curiosity. The principal line indicated was that of sodium, which must have been due to the material of the lining. Some other lines flashed out momently, now and then, and disappeared, masked in the continuous spectrum of the white-hot gases.

In 15 or 20 minutes, the marvellous illumination ceased more suddenly than it had begun. The volume and brilliancy of the flame diminish together with startling rapidity. So great is this almost instantaneous change, that it can be discerned "in the night time," says Lieut. Dutton, "at a long distance from the foundry, and from any position commanding a view of the tall chimney, or even of the glare from the doorways, no direct view of the flame being necessary." This change of the Bessemer flame is still a puzzle to chemists. It does mark, it is true, the elimination of most of the carbon, but not of all; and it is inexplicable that the combustion should cease so suddenly while there is yet fuel left. Theory apart, however, the critical moment in practice is indicated by this change. When it arrives, the blast is stopped, the converter is turned upon its side, and 600 lbs. of melted spiegeleisen are turned into it, as the pig was previously charged. The reaction is instant and violent. The manganese of the spiegeleisen combines with any sulphur that may remain in the bath, forming compounds which pass into the slag. It also decomposes in the slag silicates of iron, taking the place of the iron and returning it to the bath. Finally, the carbon and manganese together reduce the oxide of iron formed during blowing, which would destroy the malleability of the iron.

THE DISCHARGE.

All this is done in shorter time than I occupy in describing it; and now the gigantic converter, like a monster weary with drinking boiling iron and snorting fire, turns its mouth downward, and discharges its contents into a vast kettle, or ladle, brought underneath for the purpose by one of those intelligent cranes, that stand around so silent and so helpful. The ladle is swung over the moulds, and the white, one would almost say transparent, metal is drawn off into these through a tap-hole in the bottom. The heat is over. Five tons of cast wrought iron (or soft steel, if you will) have been made in 20 minutes. The actual production of these works is 1,000 to 1,200 tons of ingots per month, which is nearly twice as much as that of an English plan of the same capacity of converter. The difference is due to the admirable arrangements and improvements of Mr. Holley, which greatly reduce the loss of time in repairs and handling. The number of workmen now employed is 200. The capacity of the whole works, when the blooming-mill is completed, will be about 18,000 tons of blooms per year.

THE "Miner's Journal," of Pottsville, says if all the anthracite collieries were in full work, coal would fall to $2.25 per ton at the mines. To prevent this decline, the owners and operators of coal mines hire the operators to strike, a great portion of the summer season, and then when the cold weather comes, advance the price of coal because the stock is light. This enables us to account for the high price of coal.

THE Hopewell furnace, Bedford county, is now producing 40 tons of the best charcoal iron weekly.

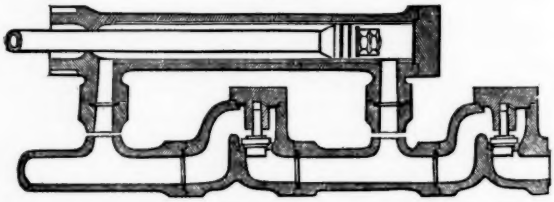
TRANSFER OF POWER—ACCUMULATOR SYSTEM.

From "The Mining Journal."

This system furnishes the means of transferring from one point to another an accumulated amount of power, and of applying it to rotary or reciprocatory purposes. The apparatus consists of a prime mover in the form of a steam or water engine, a set of charging pumps, a large plunger with weight box, a main of pipes, and pumping or winding engines. The pumping-engine used for charging the accumulator consists usually of a pair of horizontal steam cylinders, with two force pumps, which are supplied with water from a cistern set in the engine-room. Instead of employing single-acting charging pumps double-acting ones may be used as shown in Fig. 1.

In this arrangement the out-stroke of

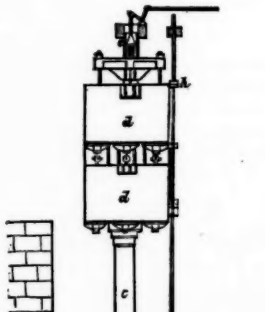
Fig. 1.



the pump causes the water contained in the annular space surrounding the plunger, *a*, to be forced into the pipes, while a further supply of water enters behind the piston, *b*, through the suction-valve, *d;* in the in-stroke the water behind the piston is discharged through the delivery valve, *c*, and half passes around the annular space on the other side of the piston, while the remaining half is forced into the pipes, the area of the plunger, *a*, being half that of the piston, *b*. The large plunger and weight-box designated an accumulator is exhibited in Fig. 2.

a, cylinder with plunger; *b c*, loaded weight boxes; *d*, guide for ditto; *e*, pipe from pumping engine; *f*, pipe to hydraulic engines. The load upon the plunger is usually such as to give a pressure of from 300 to 500 lbs. per in., whilst the case is made sufficiently capacious to contain the largest quantity of water which can be drawn from it at once by the simultaneous action of all the hydraulic machines with which it is connected. Whenever, also, the charging pumps force more water into the ram case than passes directly from it, the loaded plunger rises and makes room in the cylinder for the surplus; but when, on the other hand, the supply from the charging pumps is less than the quantity required, the plunger, with its load, descends, and makes up the deficiency out of store. The weighted plunger is also made to serve as a regulator to the engine by operating on a weight, which is arranged so as to open or close the throttle-valve in the steam pipe. The hydraulic main is usually formed of wrought-iron pipes,

Fig. 2.



screwed into strong cast-iron flanges, the latter recessed so as to receive a ring of gutta-percha about $\frac{1}{4}$ in. diameter. In this way joints are rendered tight for very long distances, even although subjected to a continuous pressure of 500 lbs. to the in. Wrought-iron pipes may also be

readily bent when cold, so as to conform to the variable line of a level.

One of Darlington's pumping-engines for draining winzes consists simply of a cylinder, a ram, two side rods, a bar-valve, two regulating cocks, and cantilever. The weight of a 2-in. ram engine, 3-ft. stroke, is about 90 lbs. The speed at which the engine may be driven is 16 strokes per minute, and under a pressure of 500 lbs. per sq. in. it is capable of working a pump 8 in. diameter to 10 fathoms deep, or one of nearly 6 in. diameter 20 fathoms deep.

In the hydraulic main a constant pressure is maintained, and the momentum occasioned by the return of the stroke relieved by means of a lifting valve-lever and weight, similar to an ordinary safety-valve, but instead of a non-elastic connection between the lever and weight a spring is interposed, of sufficient elasticity to support the weight.

By this means the inertia of the weight is prevented from checking the sudden motion of the valve when acted on by the momentum transmitted through the water. Several advantages are offered by the accumulator system ; as, for instance, mountain streams may be arrested, and applied to drive a wheel, the power compounded and transferred over broken or hilly ground. The transfer main may be of very small diameter, and sufficiently light to be fixed in the roof of a level. Winding and pumping-engines, with cylinders of small diameters, will occupy but little room, and exert a large amount of power. The friction of the water is inconsiderable, when compared with the greatness of pressure which may be used. Little or no water need be wasted in effecting the transfer of power, since it can be returned to the charging-pumps, and continually circulated. Inconvenience and nuisance arising from the use of underground steam-engines may be avoided, and all the advantages derivable from their use secured. Machinery of this class need suffer no derangement from frost, since all risk in this respect may be avoided by placing the apparatus in buildings, or below the surface of the ground ; and in cases where this is impossible accidents can be prevented by letting out the water as soon as the machines are stopped.

EXPERIMENTS WITH A DECENTRING APPARATUS.

Abstract Translated from "Annales du Conservatoire."

In 1847, M. Beaudemoulin, *Ingénieur en Chef des Ponts et Chaussées*, made use of sand in decentring arches, applying its peculiar property when in its ordinary state of division of not conveying appreciable strains to its envelopes, even when under the direct action of considerable weight.

At first linen bags were successfully employed; afterwards iron cylinders filled with sand were used, upon which the pressure was distributed by means of a wooden piston. The first application of the cylinders was made in 1854, at Paris in the works of the Pont d' Austerlitz. Since that time they have been frequently employed. In 1864 and 1865, Marèchal made use of sand bags on a railroad at Brest and found them simple in use and economical.

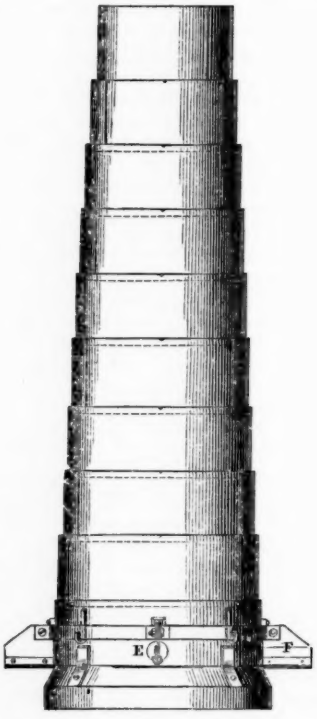
M. Beaudemoulin, seeing in 1855, at the Pont de l'Alma, the action of cylinders for decentring, noticed defects of which he gave an account in the "Annales des Ponts" (March 20). At the same time he observed important qualities in them which had been even considered as defects, and from these he deduced a new and important process, which he calls *differential*, which can be employed for as short periods as may be desired ; a great advantage in security and precision of working.

This method has become of general application. It was first employed at Paris in 1857, in the simultaneous decentring of the three arches of the Pont Saint-Michel, when 192 cylinders of sand placed at the points of support were made use of. With the old methods as many workmen would have been necessary; but in this case only a dozen were required, and the operation was successfully completed in two hours.

In 1866, M. Beaudemoulin exhibited at the Great Exposition a new apparatus, superior to that of the iron cylinders then employed, in regularity, precision, and

security of working. We have lately tried the action of this apparatus with two sets, one a model 0.161m. in diameter and 0.0015m. in thickness, the other a practical working apparatus, 0.314m. in diameter.

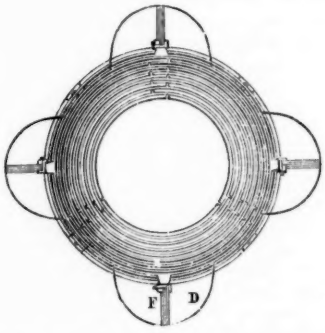
The model consists of 9 rings. The lower ring 0.155 m. in diameter and 0.056 m. in depth is fixed in a socket of wood, and is pierced with four holes 0.015 m. in diameter; below each of these a small horizontal piece called *bavette* is fixed.



This first ring is surrounded with a movable collar carrying four vertical fans disposed in such a manner that a slight displacement of the collar causes these fans to sweep off the cones of sand from the bavettes. This circle has play enough so as to slide easily. The first piece is also pierced near its upper edge with four holes about on a level, intended for the pins for holding the second ring while the apparatus is being set up. The other eight rings differ only in the absence of the orifices of discharge and of the collar. The dimensions are given in the following table:

Number of rings.	Height of ring.	Mean exterior diameter.	Mean interior diameter.	Height of pins above base.
	m.	m.	m.	m
1	0 056	0.161	0 155	0.050
2	0 054	0.151	0.148	0 055
3	0.054	0 145	0.142	0.044
4	0 053	0.139	0.136	0.048
5	0 054	0.132	0.129	0 048
6	0.054	0 126	0 123	0.048
7	0.054	0.120	0 117	0.048
8	0.054	0.115	0 112	0.048
9	0.054	0.109	0 106	0.048
Piston.	0 053	0.102	"	"

As many sets must be used in actual work, economy is desirable; the rings are therefore centred at the forge and not by lathe. This causes irregularities that would hinder sliding, if sufficient play



were not assured. To make a play of 2 to 4 mill. sufficient, it is necessary that each ring be furnished with three outside corresponding with three interior grooves on the internal surface of the next ring. In consequence of the failure by splitting along a groove of the 8th ring of a model, M. Beaudemoulin devised another plan. He pierces each of the rings with three large holes at equal distances; then setting the rings in pairs, he puts in each exterior hole small pins with round heads, adjusting them exactly to the inner rings, and then solders them to their place. By this means the play between the rings is kept constant, and friction is reduced as much as possible.

To fill the apparatus with sand, the first ring is filled to the level of the pins; after setting these and the ring which they support, the next ring is set in the same way. Care is taken not to allow sand to get between the rings. A piston of oak, 0.102 m. in diameter and 0.053 in height, is applied to the upper surface of the sand. The total height is 0.470 m.; when the rings are shut together this is reduced to 0.085 m.; giving a total play of 0.385 m.

It is an important fact, with reference to the charge of 12,504 kilog., th t in the first experiments the four orifices of discharge were closed by four squares of paper held by a cotton thread passing over their centres and tied about the collar. Several experiments having shown that the paper was sufficient, it was afterwards employed, and the first cone of sand was allowed to form freely.

M. Beaudemoulin made use of four cones to insure the vertical position of the system. The total volume was 22.2 cubic centimeters. The mean exterior diameter of the column being 0.129 m., the mean descent for each *sweeping* is

$$h = \frac{0.0000222\text{m.}^3}{0.0135\text{m.}^2} = 0\text{m.}00169,$$

which justifies the name *differential* given a process which causes the descent of a load by insensible fractions. It is possible to approximate an infinitesimal discharge by removing three fans so as to sweep off but one cone; then by setting the fans so as to sweep off but a small portion of the cones, which would immediately be replenished.

The descent is spontaneous under a charge of 0.25 m. to 0.26 m.; for a reduction of height, a hook must be employed to discharge the sand.

It is seen that, by the use of a sufficient number of these apparatuses, a difficult decentring can be accomplished under the best conditions, with few workmen, even with but one, who should see to it that the several descents were uniform.

To test the model to the utmost, it was placed on the plate of a hydraulic press.

The results of the experiment of June 24, 1868, were as follows. The 8th ring split along a groove under the last charge:

Total height of apparatus.	Pressures shown by manometer.	Charges.
m.	m.	k.
0 450[1]	0 000	0.0
0 420	0 200	7004.0
0.410	0 300	10506.0
"	0.350	12257.0

The results of the experiment of Aug. 28, 1868, were as follows. Under the last charge the upper ring parted:

m.	m.	k.
0.494	0.00	0 00
0.490	2 00	700.40
0 485	6 50	2276 00
0 480	12.00	4202.00
0 475	19.00	6654.00
0.470	24.00	8405.00
Rupture.	30.00	10506.00

It follows that the apparatus resisted a minimum pressure of 10.500 kil. They were subjected to pressure until one of the rings broke, and yet the sand did not escape. The four small squares of paper which closed the orifices, held by a fine thread, were not moved by these charges.

This is a remarkable fact, from which Beaudemoulin concludes that the lateral pressure of the sand is nothing, or nearly nothing, in that portion which is distant 20 centimeters below the piston. Putting R for the co-efficient of rupture, the formula for the resistance of cylindrical tubes of thickness e and interior diameter d is

$$2eR = pd.$$

This gives for the pressure per square metre

$$p = \frac{2eR}{d} = \frac{\times 9.000027 \times 40{,}000.000}{0.112} 9642.8 \text{ kil.}$$

The charge on the base of the upper ring being 10.500 kil., is $P = \frac{10.500}{0.009847}$ per square metre, giving between $p \times P = 1066300$ an approximate ratio

$$\frac{p}{P} = \frac{9642.8}{1066300} = 0\ 00904.$$

Hence the lateral pressure is not more than one 110th of the pressure at the top. M. Beaudemoulin thinks that this lateral pressure is due to imperfect mounting of the apparatus; that if it were set exactly vertical and were filled with perfectly dry sand uniformly distributed, there would be no lateral pressure whatever.

Appratus 0.314*m. in diameter.*—This is of dimensions sufficient for actual decenterings ; the results of experiments will therefore be of greater interest to engineers. The number of rings is three ; the thickness of the cylinder is more than double that of the model.

	Number of rings.	Kind of sand.	Descent of piston.	Maximum pressure.
	m.	m.	m.	m.
1	0 11	0.306	0.10	0.0040
2	0.11	0.295	0.10	0 0025
3	0 11	0 282	0 10	0.0025

The total height of the mounted apparatus is 0.47m. reducing to 0.16m. when all the sand is discharged. It had done service under a pressure of 300 kil. ; exment showed that it could resist a greater pressure. We tabulate the principal experiments.

Number of experiments.	Kind of sand.	Descent of piston.	Maximum pressure.
I.	River sand.....	0m.015	17510k.
II.	Do., ...	"	23113
III.	Do., ...	"	19261
IV.	Do., ...	"	19261
V.	River sand sifted...	"	"
VI.	The same sand....	"	26265

These experiments show that a charge of 26,000 kil. does not put an undue strain upon the cylinders, and that the rings of plate iron, which, with the exception of the lower, have a thickness of 0.0025m., reduced to 0.001m. in the grooves, suffered no appreciable deformation. Each of these experiments furnished special results, which we will state.

(1.) The apparatus was placed on the plate of a hydraulic press with its frame removed, the piston being held by a stone dressed to the proper level and projecting from a wall which could not be disturbed by the pressure. The sand was dried and sifted. At the close of the experiment it was found that a collar of sand 0.003 m. high had formed between the piston and the inner surface of the first ring. It could not be ascertained whether the piston had only pressed down the sand directly below leaving this ring behind it, or whether it had been partly pushed up by the pressure.

In this as in all the other experiments the orifices of discharge were left open, and the little cones which had formed before them outside while the cylinders were filling, had sufficed to prevent the sand from escaping even under the greatest pressure.

(2.) The same formation of a ring. Charge of 23113 kil.

(3.) Especially designed to show its efficacy in decentring After reaching a pressure of 19261 kil. the cones of sand were swept off by the sweeping collar. The sand always escaped with great regularity, and at the end of the operation (limited by the play of the piston) the piston had descended in the third ring 0.073 ; this third ring had sunk in the second 0.089m., and this in the first 0.045m. ; a total descent of 0.207 m.

(4.) Under a charge of 19261 kil. the piston descended 0.010m. before discharge. The sand escaped easily when the cones had been swept off ; but the discharge ceased as soon as pressure was taken off. It was found upon examination that there was cohesion in the sand, increasing from the centre outward.

(5.) River sand was carefully dried and sifted twice to get rid of dust and smaller particles. After discharge the sand was again sifted, and it was found that there were 18 litres of coarse sand, 1.5 litre of fine, partly reduced to dust ; that is, pulverization was produced in the ratio $\frac{1.5}{19.5}$ This sand left the fingers white after the pressure, but not before.

(6.) The pressure was put on to 26265 kil., and maintained for 15 min. at 24515 kil. After discharge it was observed that the white powder due to pulverization was uniformly distributed throughout the mass. Sifting gave 17 litres coarse sand, 4 litres fine. Before discharge a plate of metal was vertically inserted in the sand, and it was found at all points so agglutinated as to sustain itself without talus.

THE Belgians are entitled to the credit of having built the first high-blast furnaces. They introduced them into England in the middle of the 15th century; and in 1612 Sturtevant obtained a patent in England for smelting iron with bituminous coal ; previously charcoal was used, and only 2 or 3 tons of iron could be made per day with one furnace.

METALLINE.

We extract from the columns of "Engineering" the following patent specification, which presents in full the theory upon which the manufacture of metalline is founded:

This invention of "Improvements in the treatment or preparation of various natural substances so as to render them applicable for use in journal boxes and other parts of machinery or other articles whose services are intended to be subjected to friction," relates to a new and useful process for treating certain natural substances by which they are produced in such conditions that while they possess that degree of solidity which is necessary to bear (without material change of form) the pressure ordinarily applied to journal boxes and other articles whose surfaces are intended to be subjected to friction in machinery and elsewhere in the arts, at the same time so little friction will be actually caused and so little heat thereby developed in the practical use of such articles made of them that all necessity for the application of oil or any other lubricant to their surfaces will be entirely obviated.

The description will be more readily and clearly understood by first stating certain familiar elementary facts and principles involved in the phenomena of friction, and the development of heat thereby.

All matter is supposed to exist in its ultimate form as indivisible atoms held together by a force called the attraction of cohesion, but nowhere are these atoms actually in contact with each other, such contact being prevented by an antagonizing force called repulsion, leaving vacant spaces or interstices between them. In proportion as these atoms in any aggregation of them are drawn more nearly in contact does the mass become solidified, or, in other words, just in that ratio is their tendency to maintain a fixed relative position, and is the difficulty increased of causing them to move around and upon each other. The more widely they are separated from each other the more plastic, yielding or fluid does the mass become, and the less is the force required to cause movement among the atoms; or, in other words, just in proportion to the nearness of the atoms to each other is the energy with which the two forces act, repulsion to resist a further approach, and cohesion to prevent separation, the combined action of the two being to hold the atoms fixedly at the point where these forces balance each other. But whatever may be the atomic condition in the respects named, however slightly or however rigidly the atoms may be held together in a fixed relative position, so long as they remain within the sphere of the action of the forces named, some expenditure of a counterforce is neccessary to cause movement among them, the amount in every case depending of course upon the energy with which cohesion and repulsion are acting. In some kinds and conditions of matter there is that peculiar action of cohesion and repulsion, as in most crystalline bodies, which causes the atoms to have so strong a tendency to maintain a fixed relative position, and to resist inter-atomic movement, that less force is required to detach them completely from each other than to effect a change of position among them. Such substances are brittle and unyielding; they refuse to submit to a change of form except by abrasion, or by being broken or crushed in pieces.

Cohesion and repulsion act only at insensible distances, but whenever any two atoms of matter approach within a certain distance they do invariably act, and a counterforce must be employed to disturb the atomic arrangement which they effect.

Adhesion is commonly understood to be that tendency which the atoms or particles of one mass of solid or semi-solid matter have to stick or adhere to those of another. It (in fact, however) only differs from cohesion in the condition under which it takes place, adhesion acting between the atoms of one mass, and those of another cohesion between those of the same mass. Cohesion and adhesion are therefore really the same force or property. The energy with which adhesion in any case acts is (as is true of cohesion) in proportion to the nearness to which the atoms of the one surface are made to approach those of any other, and therefore it is only between masses that are (one or both) in some degree plastic or yielding that it takes place. But between all such substances it does manifest itself to a

greater or less extent, and therefore this property of matter plays a most important part in the phenomena of friction, and the heat thereby developed, as will presently appear. Heat is but a mode of motion, and all motion is caused by an expenditure of force ; hence it follows that there can be no expenditure of force without the development of heat, and an amount of heat that is exactly the equivalent of the force expended. Heat in its manifestation among the atoms of matter acts to drive them asunder, thus diminishing cohesion, and tending to facilitate change of relative position among them, and determining their condition as to solidity and fluidity of their masses. But as the articles (for which the compositions made by the process are to be used) are used generally at the ordinary temperature of the atmosphere, it is not necessary here to take into consideration the molecular changes effected in matter by heat other than those occurring from that degree of heat developed by friction in the actual use of these articles ; but with reference to such heating it is important to bear in mind that most solid or semi-solid substances are rendered more plastic by heat, and in proportion to the degree of heat present is the tendency to adhesion between the surfaces of two heated masses. In the light of these familiar principles it is not difficult to apprehend the philosophy of friction and its resulting heat. It is obvious from its atomic constitution that no mass of matter can be made to present a surface that is an absolute plane ; even if it were possible to level down all asperities formed of aggregates of atoms there would still be atomic prominences and depressions. But practically it is impossible to polish away entirely all inequalities other than those resulting from atomic structure. Now when two surfaces that are not absolute planes are rubbed together as nearly in contact as possible, or rigidly held from receding from each other, whatever inequalities or prominences there are must present obstacles to free movement. They will clash together, impinge against each other, and when they thus come into collision the motion of the surfaces must be arrested, or sufficient force must be applied either to break off and detach the colliding atoms or aggregate of atoms from the masses to which they cohere, or to change their position and depress them so far that they can pass each other. If they become detached they will still continue to be obstructions to the free motion of the surfaces, cutting into and roughening them, augmenting the difficulty of their movement, and calling for increased expenditure of force, which results of course in an increased development of heat. If the mass is so far plastic or yielding that no detachment or abrasion takes place, the atoms must be made to change their relative position ; then an undulatory motion may occur, the depression of those most prominent causing the elevation of others in their vicinity, they to be in turn depressed, and so on continually while the rubbing of the surfaces together is continued. But this molecular undulation demands the expenditure of force to produce it just in proportion to the resistance which cohesion among the atoms opposes to it, and of course the equivalent of this force will appear as heat. Still another obstacle to the free movement of the surfaces upon each other exists, namely, adhesion, which plays a most important part in friction. If any surface is brought so nearly to a plane that a considerable number of the atoms composing it are caused to approach so nearly in contact with those of another (that is, being rubbed upon it) as to bring them within the sphere of cohesive attraction, the two surfaces have a tendency to adhere together. The expenditure of force is then required to prevent them from doing so, and heat will of course result from such expenditure of force.

We have now before us what is believed to be the true philosophy of friction and heat resulting from the rubbing of one mass of matter upon another, and it discloses a most important fact, a fact which is the key to the new process. It is this, that always and everywhere friction is the resistance which the cohesion and repulsion, one or both, of the atoms of the bodies whose surfaces are being rubbed together (which, for convenience, I will call elemental force) offers in some way to the force expended to cause the movement of the surfaces (which, for like convenience, I will term mechanical force), and the heat developed by the friction is the equivalent in another form of the mechanical force thus expended.

It is not, of course, difficult to find con-

ditions in nature or to produce them by art in which these forces, one or both, act with little energy, and where there is consequently little friction. Most of the fluids present them, but these are not the only conditions demanded in substances that are to be used for journal boxes and other similar articles. There is demanded a certain degree of solidity (required to prevent change of form under the pressure to which these articles are to be subjected), and it is difficult to find or produce a substance having the last-named property which is at the same time of such a nature that so little friction is caused by rubbing its surface that when employing it for the purpose of journal boxes in machinery the use of a lubricant can be dispensed with. In fact, nature, so far as is known, has not given us such a substance, and it has not heretofore been thought possible to produce it by art. I have discovered it is, however, possible to do so, and by the improved process such a substance, or rather a series of substances, is produced as by experiment and trial has been now abundantly demonstrated. To the substances so produced is given the name of "metalline."

In describing the mode of treating a great range of materials so as to produce the important result stated above, I shall assume that this description is given to those who are acquainted with the natural properties belonging to the elements and substances treated, whether simple or compound, and with what our present science teaches of their possible changes and modifications under the action of chemical laws and mechanical forces.

The properties requisite in a substance to render it suitable for journal boxes and other working parts of machinery, and which can be used practically without a lubricant, may be stated to be the following:

First.—That degree of solidity or coherence necessary to prevent change of form to any considerable degree of the article made of it by the pressure to which it is to be subject in use.

Second.—Such a degree of plasticity or facility of movement of the atoms or particles over and upon each other that the expenditure of force sufficient to cause so much of the movement as results from such rubbing practically in machinery shall not develop heat more rapidly than it can be conducted away in the atmosphere at ordinary temperatures.

Third.—Just such a degree of non-plasticity or fixedness of the relative position of its atoms or particles, and a repulsive tendency between its atoms and those of the journal-box or other opposing surface, that adhesion between its surface and that of the body rubbed upon it in practical use will not take place to such an extent that the heat caused by overcoming it will not be radiated away as rapidly as it is developed.

Fourth.—Such an adjustment or balance of the three preceding conditions that little or no abrasion or wear, *i. e.*, change of quantity of the journal-box or shaft, shall take place.

To combine these conditions in one and the same body is the object to be secured. To secure it, I take some natural substance, which, if it have sufficient solidity for the purpose, will invariably be found to have too much coherence; that is, it will have either too rigid and unyielding an atomic structure, so as to crumble and wear into powder by rubbing, or it will be non-coherent to such a degree, that it will exist as a sand or powder, or it will be too adhesive, so as to stick or cling to the body being rubbed upon it to such a degree as to cause too much friction. Its natural conditions in this respect must be changed or modified by first destroying its natural coherence (if it exists in masses which cannot be controlled), and then establishing an artificial union among its particles which can be controlled. To this end the atoms are sundered as far as possible from each other by solution and precipitation by heat, by abrasion, or by trituration, or by some other suitable method, if the material used requires this treatment. The nature of the substance in hand will determine the particular method employed, the object being to break up and destroy its natural coherence. If the substance is not one whose too great original coherence was due to the presence of some element the removal of which merely will effect the desired modification, or one whose molecular structure it is only necessary to change by heat, electricity, pressure, or some other temporarily acting modifying agent. I then proceed to intimately mix or combine with it another substance, one that has naturally comparatively but little

coherence, and which is susceptible of intimately commingling with its particles, and surrounding, or infiltrating, or interposing itself between them, so as to prevent by any means their consolidation into their original natural state. Then the compound thus prepared is to be subjected to just that degree of pressure requisite to impart to it the necessary solidity to prevent crumbling under friction, or to any considerable extent changing form under pressure when put to use as a journal-box. Pressure at this stage is important also because it tends to produce a more intimate commingling, a more equal distribution, and a finer interadjustment of the particles of the several elements of the compound. This pressure may be applied in a suitable mould to give the body the desired solidity, and most conveniently by an hydraulic press.

If the substance in hand is embraced in the class of compounds included in the exception first above named, a knowledge of the nature of its elements will readily disclose that one to which is due its too great adhesiveness. This adhesive element is then to be removed in whole or in part, or modified, as may be necessary, by means properly adapted to do so, which the expert will know how to select and apply, and just how much of the element must be removed to secure the conditions required as above set forth will, of course, depend upon circumstances; but, knowing the nature of the substance under treatment, and the precise object aimed at, as hereinbefore defined, the expert here will have no more difficulty in successfully performing this needed manipulation of the substance, than does the expert in machinery in calculating and adapting the different parts of a machine to secure a given result. When the substance has undergone the change indicated, it is then to be subjected to pressure as before described.

If the substance belongs to the class included in the second of the above-named exceptions, then the same knowledge of its nature above supposed to be possessed by the expert will enable him to apply the requisite modifying agent successfully to effect the object aimed at.

If the substance employed be a brittle or friable one, and is already in a powdered or disintegrated state, then is to be united with it another capable of becoming intimately disseminated among the particles of the powder and in some measure adherent to them, and having sufficient coherency among its own atoms to be susceptible of becoming aggregated with such particles into a mass by pressure, which, while it has sufficient solidity to answer for a journal-box or journal-box lining, at the same time has just that degree of facility of movement among its atoms and particles hereinbefore stated as requisite. The aggregating substance may be one which alone has too much coherence and plasticity to itself make a journal-box that can be used without a lubricant, but which in its combination with the powdered material will have its coherence reduced and its plasticity modified so as to produce the required conditions.

Now having stated the principles and method to proceed upon in the process, I will give a number of illustrations of its use. [The inventor here gives 15 examples, of which, however, we only quote the following:]

Example No. 1.—In this example take of iron 50 parts in such a state of division that it will pass through a sieve with at least 10,000 holes to the inch. It is well to protect the surface of the particles of the powdered iron from oxidation before it is compounded with the tin by covering them with any oily substance. Half of one per cent. of paraffine intimately mixed with the iron dust in a heated mill will prevent oxidation of the particles for months. Then take of tin 50 parts, which it is preferred to have as finely divided as the iron, but its high pulverization is not so necessary as that of the iron for obvious reasons. These metals are then intimately mixed by grinding or otherwise, and the mixture subjected (in steel or other suitable moulds) to pressure to give it the required solidity, say about 60 tons per superficial inch. The required consolidation will be determined by the use to which the resultant "metalline" is to be applied. The proportions given will be found to be those most generally serviceable, but they may be varied to meet the various conditions under which the metalline is to be used.

* * * * * * *

Example No. 15.—In this example the breaking to a certain degree of the natural cohesion of a metal is effected by

heat alone, and while the metal is held in a state of molecular disintegration by a continued application of the proper degree of heat, another substance having slight cohesion among its own particles is introduced among the atoms of the metal, which interposes a barrier to the restoration of the natural cohesion of the metal when the heat is withdrawn. To this end take a metal which between its solid and melted state is susceptible of a semi-fluid condition, in which it is found to be plastic, easily moulded, somewhat granular, and only feebly coherent. Such a metal is the common plumbers' solder. When this metal is heated, and just before it reaches the melting point, mould or stir into it a small quantity of carbon graphite (blacklead), or some equivalent substance; 3 to 20 parts of the carbon graphite with 80 to 97 parts of the solder will be found to be a serviceable proportion. The two should be intimately incorporated together, the heat of the metal being meantime maintained at the proper point, and before it is so far cooled as to become solidified the mass should be subjected to pressure in moulds to give it such shape as may be required for use. When a metal or alloy has thus been incorporated with the graphite or any equivalent substance for the purpose here intended, it should not be thereafter melted, as the two will immediately separate on being completely fused. When a change of form is desired, raise the temperature to near the point of fusion, and then press the mass in moulds of the required shape. There are many substances that will be found to be the equivalents of the carbon graphites for the purposes just described, those which are susceptible of being reduced to fine and impalpable powders, for examples, many others of the graphites, the precipitated metallic oxides, etc. The graphites are sometimes used for convenience when not reduced to a very fine powder, and are valuable adjuncts in making metalline.

I may mention in a general summary among the articles that will be found serviceable in preventing the restoration of the natural cohesion of metals or alloys after such cohesion has been broken up as described, the graphites, paraffine, beeswax, spermaceti, and caoutchouc. Gutta-percha, gum ballatta, oleaginous substances may be used, as they operate to coat and envelop the particles of the metals, thus preventing cohesion between such particles, and also between the journal box made of metalline and the journal. Gum resins, such as shellac copal, are often found useful in imparting additional cohesiveness where the cohesion is too feeble. Nearly 5,000 varieties of metalline have beenmade, and it is obvious that, drawing our resources from the vegetable, the animal, and the mineral kingdoms, the entire realm of nature (and examples of each have been given), many millions of varieties of metalline may be produced.

In each of the examples now specified there is a large class of substances that may be substituted for the principal elements named, and which when substituted for them respectively will be found to be equivalents. Of course all equivalents of the several substances named in the several compositions respectively are claimed.

What I claim and desire to secure by Letters Patent is:

First.—The process herein set forth of selecting, treating, compounding, and consolidating certain substances, by which are produced new compositions of matter (denominated by the inventor "metalline") designed for the purpose of journal boxes and other parts of machinery, and other articles whose surfaces in use are subjected to friction, and which substances possess such properties and conditions that in the practical use in machinery and elsewhere in the arts of such articles made of it, so little friction is actually caused and so little heat thereby developed, that all necessity for the application of oil or any other lubricant is entirely obviated, as herein set forth.

Second.—I claim each of the several compositions of matter hereinbefore described when respectively composed of the substances specified or their respective equivalents, and compounded and consolidated in the manner described, or ang other manner by which an equivalent effect is obtained for the purposes named.

It is said that there is a prospect of the new rolling mill at Portsmouth, Ohio, being re-organized to commence work again. It is said that the mill will probably prepare to make railroad iron.

IRON AND STEEL NOTES.

It appears that the Styrum (German) Metallurgical Company produced last year 19,149 tons of iron in bars and rails, 6,906 tons of plates, and 949 tons of pieces of cast-iron, making a total of 27,003 tons, against 24,616 tons in 1868. A very large iron bridge is about to be thrown across the Neva, at St. Petersburg. It will be about 1,100 ft. in length, and will probably rest on twelve or fourteen piers. The weight of the iron-work involved in the construction of the bridge is estimated at upwards of 6,000 tons.

The war checks and even interrupts in some localities the exportation of coal from Belgium, and this sad state of things will probably last some time. On the other hand, the exportation of Ruhr coal being again permitted by Prussia, Holland is now sending Belgium fewer orders for coal. The situation, then, is calculated to inspire some uneasiness. Some of the Belgian blast-furnaces and rolling-mills may possibly also restrict their production, and this would, of course, involve additional depression in the Belgian coal trade. Meanwhile, as the extraction of coal in Belgium has been somewhat moderate of late, prices maintain themselves tolerably well. The Belgian Government has not ratified an "adjudication" which took place in July at Brussels, and which comprised, *inter alia*, contracts for about 5,000 tons of Bessemer steel rails. The contracts were secured provisionally by M. Adhemar Le Roy, representing Messrs. C. Cammell and Co. (Limited), of Sheffield, and by Messrs. Tiden, Nordenfelt and Co., of London. The Belgian Government has now declined to ratify the contracts, but will let similar contracts instead to some Belgian firm. The Cockerill Company, at Seraing, is the only Belgian establishment which has appliances for the production of Bessemer steel, and will, consequently, in all probability receive an order for the rails in question.

The condition of the French iron trade has not changed very much during the last few days, but a general feeling of depression and uneasiness prevails. The forgemasters of the Champagne group have not slackened their production, and it is stated that they have decided to make every possible effort to avoid extinguishing their furnaces. In the Moselle district the Ars and Hayange furnaces have continued their operations, so far as it has been practicable to do so, having regard to the relatively limited number of men whom the war levies have spared for industrial pursuits. At present the blast-furnaces of this group have not been blown out. The advices received from the Longwy district are tolerably good, the works having a fair number of orders on hand; this group has benefited from its situation, and the intelligent measures taken in regard to it by the Great Luxembourg Railway Company, which has endeavored to reduce to a minimum the inconveniences resulting from the heavy military traffic which has been passing over the local railways. White coke-made refining pig is quoted in the Moselle at £2 18s. 4d. per ton; speckled pig, £3 0s. 10d. per ton; grey-refining pig, £3 3s. 4d. per ton; casting pig, No. 1, £4 4s. per ton; ditto, No. 2, £4 per ton; ditto, No. 3, £3 16s. 8d. per ton; ditto, No. 4, £3 13s. 4d per ton; ditto, No. 5, £3 10s. 6d. per ton; charcoal-made refining pig, £5 8s. per ton; rolled coke-made iron, £8 4s. to £8 8s. per ton; cast-iron pipes, £6 16s. per ton; solid columns, £5 16s. per ton; hollow columns, £3 16s. per ton, The sale is to be attempted this month of the Blanc-Murger forges, in the valley of the Semouse (Vosges); the sale is proposed to be proceeded with at Remiremont, on Sept. 8. The municipal authorities of Rochefort have been authorized to borrow £44,000 to provide for an improved water supply at that town. The supply proposed is to be at the rate of about 25 gallons daily for each inhabitant of the town. The Compagnie des Chantiers et Ateliers de l'Ocean has established in the Mazeline Works at Havre a special establishment for the manufacture of locomotives and tenders. Besides having various orders on foreign account, the Company is now engaged on a number of locomotives for the Western of France Railway Company. Axles of great durability are being introduced into these engines, on a principle patented by the Western of France Railway Company. An engine with these axles has been running upon the Western of France Railway for the last five years, and has run upwards of 390,000 miles without its axles exhibiting any signs of decay.

British Iron Trade.—The iron trade of this country need not be at all alarmed at the warlike attitude assumed by two of the most important nations of Europe. Instead of having them for customers of late years we have had them as rivals, and they have been sharp and active ones too. They are now about to enter upon a struggle, of which no man can say when it may end, and which will require all the resources of the two nations, and all the youngest and best blood of their populations. From the arts of peace they will now have to turn to the art of war, and their necessity will be England's opportunity. The withdrawal of a large part of the populations from the iron trades of France and Prussia will naturally throw a good deal of work into this country. We know very well what the effect would be upon the iron trade of Great Britain, if we had to withdraw our iron-workers from the mills and furnaces of the iron districts and turn them into soldiers or sailors. We should then be forced to fall back upon the resources of these very continental nations who have for years past been our active rivals, and then our necessity would be their opportunity. All we have to do is to keep out of the quarrel ourselves, and let France and Prussia do the fighting whilst we do their trade. And, as the "Economist" well puts it, "the gain to English trade will be considerable in various ways. The use of capital on a large scale which was spreading of late so rapidly through Northern Europe, and was daily bringing more and more competitors into profitable markets where English manufactures had been used to certain superiority, is for the present arrested. We shall now once more have an indisputable pre-eminence in many trades, such as we have not had for years, and such as it was not likely we should again see. A vicious speculation in the raw material of our principal manufacturing industry has been broken up. A great trade will set in in instruments of war, which, in spite of declarations of neutrality, both belligerents will wish to buy here, and which we shall in fact sell to both of them. All the carrying trade will be in our hands. English vessels will be able to keep the sea, while both French and German vessels will be a prey to hostile cruisers. And we shall have an augmented commission trade too." Therefore, instead of the

iron trade being threatened with a serious check, as some newspaper writers assert, a renewed prosperity is in store for it. The reports which we have received from the various iron districts, show a continued briskness in all departments; and as regards prices they are still firm. The shipments of iron, on foreign account, from the ports of Middlesbro', Cardiff, and Liverpool, keep well up, and the home demand for iron for railway and engineering purposes is much stronger. With regard to the labor question, we do not think there will be any disturbance in North or South Staffordshire, and the present agitation seems to be waxing weaker every day, and will soon melt away altogether.—*Mechanics' Magazine.*

A Model Iron Works. The Works of Sir John Cockerill and Co., Belgium.—We have in a previous Journal published a brief account of these important works; we are now, however, in a position to give a full description with most minute particulars of this model establishment of the world. The statistics are translated from a statement handed to us by M. Pastor, one of the head managers, and the gentleman who acted as guide to the party of mining and mechanical engineers who lately visited Belgium. We have not thought it necessary to convert the French moneys, weights, and measures into English, as it would only cause a complication of decimals if done correctly, and we are quite sure our readers are sufficiently conversant with them to thoroughly understand the particulars.

John Cockerell, who, by the by, was an Englishman, established the works at Seraing, in 1817. He started in a small machine shop, in a very small way; but the works have gradually grown till they now occupy the whole of the extensive gardens of the ancient bishops of Liege, the present offices have been the fine old palace, so that it makes a noble front for the works, which are situated on the banks of the Meuse. This Company carry out the whole operations, from the raising of the coal and minerals to the turning out of the finest engines, bridges, iron-clad ships, etc. The general director is M. Sadoine. The area covered by the works is 90 hectares, one-eighth of which is entirely taken up by buildings. The number of persons employed in 1867 was 7,277. They pay annually for salaries 6,660,000 francs, and employ 156 steam-engines, of the collective nominal horse power of 2,843. The yearly amount of work constructed is valued at 25,000,000 francs, and the quantity of fuel consumed is computed at 220,000,000 kilogrammes. The collieries employ 2,157 persons, and steam-engines of 628-horse power. There are four separate places of extraction, and eight pits or shafts used for raising the coal, ventilation, and the descent and ascent of the work people by means of the fahrkunst, or man-engine. From these pits are raised 260,000,000 kilogrammes of coal. They employ 195 men and women to convert coal into coke, and steam-engines of 87-horse power. There are five lots of coke ovens (of two classes), six stamps or pounders, two washing machines, and eight steam drying furnaces, for preparing the coal before it goes to the ovens; 80,000,000 kilogrammes of coke are produced annually.

In the mines are employed 875 operatives, and steam-engines of 224-horse power. There are 30 places where the mines are extracted, in the provinces of Liege, Namur, and Luxembourg, and the total amount produced yearly is 146,000,000 kilogrammes. There are five blast-furnaces, with steam-engines of 548-horse power, and employing 288 persons. The blast-engines are very powerful, and produce a pressure of blast equal to 3¼ lbs. to the sq. in. The boilers and hot-air furnaces are heated by the waste gases. The annual produce of iron amounts to 50,000,000 kilogrammes. In the foundries 256 work-people are engaged, and the engines are of 32-horse power. There 8 cupolas, and 800,000 kilogrammes of moulding boxes. They have two separate buildings for core making and drying; 5,000,000 kilogrammes is the weight of castings turned out annually. In the iron-works—that is, the mills and forges—985 operatives are engaged. The steam-engines are of 532-horse power. There are 68 reverberatory furnaces, 13 rolling mills, and 5 hammers. Plates and sheets, merchant iron, and specialties are produced yearly to the total weight of 10,000,000 kilogrammes, and rails to the amount of 25,000,000 kilogrammes, making in all 35,000,000 kilogrammes. The steel works employ 191 work-people, and steam-engines of 520-horse power. There are two large Bessemer converters, 5 ordinary furnaces, 24 casting furnaces, 15 reverberatory furnaces 7 hammers from ¼ to 15 tons, one rolling mill of very large dimensions, and two rolling mills for railway wheel tyres, fitted with all necessary hydraulic apparatus. The annual production amounts to 7,500,000 kilogrammes of wrought and cast-steel, steel rails, tyres in steel and iron, and steel castings for machinery.

In the iron forges, engine and machine shops, there are 1,184 persons employed, and engines of 224-horse power. There are 23 reverberatory furnaces, 13 steam hammers, 230 lathes, 18 slotting machines, 84 planing machines, 90 drilling machines, 5 machines for forging nuts and bolts, and 3 hydraulic presses. The quantity of engines and machines constructed annually amounts in weight to 7,000,000 kilogrammes. The boiler and bridge yards employ 573 persons, and engines of 42-horse power. There are 18 drilling machines, 35 punching machines, 7 sets of rollers, for bending plates, and 20 shearing, planing, multiple drilling, and riveting machines; 4,000,000 kilogrammes of steam boilers, bridges, etc., are made annually. In the Antwerp shipbuilding yard 319 persons are engaged. There is one steam-engine of 8-horse power, special docks for all classes of marine constructions, shipbuilding sheds of glass, rafts and boats, machines for masting, stocks, and launching cradles, both for sea-going vessels and river boats. The weight of marine constructions made nearly amounts to 2,000,000 kilogrammes. From 750 to 800 operatives are employed in the St. Petersburg yard, and it is furnished in every respect similarly to the Antwerp one. The annual productions weigh 1,500,000 kilogrammes. There are 111 managers and clerks belonging to the establishment. The area of the works is divided in the following manner: The Seraing works cover 72 hectares, the Antwerp yard 5½ hectares, that of St. Petersburg 1½ hectares, and their own mines 11 hectares. Independently of the above, they hold under Government for getting coal 195 hectares, and for getting mine 3,500 hectares.

They have constructed at the Seraing works 1,687 steam-engines of from 4 to 600-horse power for industrial applications, 975 locomotives of all sizes and systems, and 11,650 machines, forming complete works and parts of works, for raising and

reducing coal and minerals, the working of metals, for construction, sugar factories, the making of ice, paper making, weaving, bridges, suspension bridges, etc.

The yards of Antwerp and St. Petersburg have furnished for navigation 174 ships, river boats, pilot boats, floating lights, dredgers, transports, packets, floating docks for frigates of the largest size, and iron-plated monitors. The two armor-plated monitors with towers, propellers, and machines for towers, ventilators, gun carriages, centrifugal pumps, and accessories, supplied for Russia in 1864, having been ordered on June 18, 1863, were sent for finishing to St. Petersburg in October, 1863, and booked to the Imperial authorities, fully equipped and armed, after trial on June 13, 1864, having been commenced and completed ready for service in less than 12 months.

The works of Sir John Cockerill and Co. can furnish annually 50 locomotives of the first-class, 70 marine engines of from 4 to 1,000-horse power, 1,500 lots of mechanical constructions, 3,000,000 kilogrammes of bridges and like structures, 14 ships and boats, taking 5,000 tons of material, besides coal, coke, minerals, castings, wrought-iron, rails and steel in the quantities before mentioned. Every department is kept strictly apart, so that each one seems to belong to a separate proprietor.

THE declension of iron manufacture in Russia arises chiefly from deficiency of fuel, and the great distance of the mines from the centres of commerce and civilization. The iron industry in Russia owed its origin to Peter the Great, and, 150 years ago, vast mines were wrought and great works erected. The empire seems to produce every description of ore, and each in great variety. In the Altai and the Oural vast masses of magnetic ore are found. There are various other directions where magnetic ore is found in smaller deposits. Very fine ore for the purpose of steel manufacture is extracted in several districts. Ordinary ores are much more abundant, and are discovered over a wider area of country. In the centre of Russia red oxide is the prevailing yield. One great advantage is that a deep iron mine is not known in Russia; whenever the metal is found it is near the surface. It would be impossible to estimate the resources of this country in iron; probably it exceeds that of any other country in the world.

THE IRON TRADE OF FRANCE.—The accounts from Champagne are better than could be expected, considering the gravity of the events which are taking place in the department of the Haut-Marne. Some works are closed, it is true, but most of them continue in operation in spite of the occupation of the country by the enemy; all that is produced, however, remains in stock, except the small quantity wanted in the immediate neighborhood, for there are scarcely any means of transport, the railways being cut at certain points, and the navigation of the canals being irregular in the extreme. Coal has not yet run out for the furnaces, and forges had taken the precaution to lay in large stocks. But the provision cannot be inexhaustible, so that unless supplies arrive work must necessarily come to a stand-still before long. Commercial orders there are none, and quotations are nominal. In the Moselle the situation is much he same, and prices stand without alteration. There is not much doing in Paris, and the price of merchant iron has fallen fifty centimes; flooring iron is now quoted at 21f. for small quantities, main pieces are worth 27f. to 28f. On account of the want of workmen the orders are merely for the completion of works in hand; nothing new, of course, is undertaken at such a moment as this. The difficulties which exist elsewhere cause great activity in the basin of the Loire; all the works at Firminy, St. Etienne, St. Chamond, Aissailly, and Rive de Gier, are putting on all the steam available. The guards are doubled where any workmen are engaged. The house of Petin-Gaudet is still hard at work for the Government, producing all the cannon, rifles, armor plates, and balls that it can possibly turn out. MM. Manel Freres, of the Rive de Gier, are making thick plate shields for the mitrailleuse, and have just sent off forty of these shields. MM. Jacob Heltzer and Co., of Mineux and Pont Salomey, are turning out small arms and bayonets as fast as possible.

ANNEALING METALS.—According to the invention of Mr. J. M. Bottum, of England, an annealing pot of any common or suitable form is employed, within which the metal to be annealed may be packed in charcoal or other material, and the whole introduced into the furnace for heating in the customary manner. When the heating is completed the pot is removed from the furnace and placed in the improved cooling chamber, which is then closed air-tight until the gradual cooling of the metal within the annealing pot is finished. The annealing pot during this process is preferably supported at a considerable distance from the external walls of the chamber, and the cooling chamber itself is preferably supported in such a manner as to lessen or avoid any unequal conduction of heat from its various parts.—*Mining Journal.*

CASTING OF AN ENORMOUS STEEL INGOT.—That Sheffield owes much of its prosperity to the development of the iron and steel trade is generally acknowledged, and it may be fairly claimed that to the enterprise of Messrs. Thomas Firth and Sons, of the Norfolk Works, no inconsiderable share of the honor is due. It was considered a great achievement some time ago when castings were required for the Whitworth gun to produce them weighing 15 cwts., but so rapid has been the strides in scientific and mechanical appliances that now they are regularly cast of at least ten times that weight. On Tuesday preparations which had been in progress some days were completed for producing by far the largest crucible steel casting which had ever been attempted, and the arrangements were so complete as to secure the most perfect success. The casting is designed for the beam of the screw steamship Munster, belonging to the City of Dublin Steam Packet Company. The mould in which the ingot was cast was upwards of 14 ft. in length and 3 ft. in diameter, and was fixed in the middle of the principal melting furnace. About 300 men were in attendance when the interesting operations began, which were under the personal superintendence of Mr. Mark Firth. Almost military precision was observed in bringing from the distant parts of the works the crucibles containing molten steel ready to be poured into the mould. This was fixed in a central position, and close at hand were 150 "holes," with tributaries from many other parts

of the premises, and we believe that altogether there were upwards of 270 in operation. Some idea may be gathered of the completeness of the arrangements when we say that in about half an hour the contents of no less than 544 crucibles of 64 lbs. each was poured into the capacious mould, making a total of 34,816 lbs., the teeming being done by eight men. There is no doubt that is the largest that has ever been produced. We believe that the ponderous casting, which weighs 15 tons 3 qrs. 12 lbs., will not be cool enough for removal in less than four or five days.

To Unite Steel.—It is proposed by J. Abderdam to unite cast steel or Bessemer steel or case-hardened wrought iron, either by pouring the molten cast or Bessemer steel against plates or slabs of blistered steel or case-hardened wrought-iron, or he heats the bar of cast or Bessemer steel to a yellow heat, and the bar of cement, steel, or case-hardened wrought-iron to a welding heat, and places them one on top of the other under a suitable press capable of exerting a pressure over the entire surface of the bars, and by this pressure the two metals are firmly united.

RAILWAY NOTES.

Self-Acting Coupling for Carriages.—Among the many persons who have turned their attention to the prevention of accidents through shunting and coupling railway wagons, etc., is Mr. James Turnbull, a legal gentleman in Edinburgh, secretary to the Berwickshire Railway Company, who has patented and tested by experiment a self-acting coupling for railway vehicles. Mr. Turnbull's invention consists of a horizontal arm projecting in front of the hook at present attached to the draw-bar of carriages, and hinged to the bar at the breast or buffer beam of the carriage. This arm is retained in the horizontal position by means of a weighted inner-arm, and in uncoupling is moved downwards by means of a lever carried to the outer side of the wagon. In shape the new coupling may be described as like a shoe, with a slot in the sole, into which the hook of the coupling—which represents the front upper of the shoe—slides when the wagons are brought together. On two wagons being run together, the action of coupling is performed without manual assistance. The elongated points of the shoe-shaped hook, formed of hardened steel, come together, and one passes beneath the other till the slot is reached, when the weighted inner-arm brings the under hook up to the horizontal position, and the fastening is accomplished. In the case of two wagons coming together exactly level, the depression of one of the arms is provided for by the hinge on which they move being made elliptical and sloping upwards, by which means the point of the arm is forced down by contact.

The merits claimed for this invention are various. In view of the great accident at Abergele, it may be said that had the runaway wagons been fitted with this coupling they would have been attached and caught, instead of being driven off, and thus the accident would have been prevented. It is obvious that with a self-acting coupling much time, as well as many accidents, would be saved in making up trains at the depot. By the provision of a side-lever to depress the hooked arm this invention also aims at abolishing the dangerous mode of uncoupling which the existing apparatus renders necessary. Another merit claimed by Mr. Turnbull is the saving in wear and tear by reducing the distance between vehicles not supplied with spring buffers. With the new coupling the distance would not exceed two or three inches, sufficient to enable the wagons to round a curve, and saving a great deal of damage to the permanent way at present caused by excessive oscillation, and to the plant by the shocks and concussions to which it is now exposed. The goods carried would also save damage caused to them by the shaking and bumping caused by the present loose system of fastening ordinary wagons. By retaining the present hook and chain the invention is capable of being gradually introduced into new and renewed stock, and could be worked along with old plant until the adoption of the new system became general.

We have in the above remarks given expression to the intentions and expectations of the ingenious inventor, but of course the plan still waits the proof of experience and the test of economy. So far as experiments have been conducted, by means of wagons thrown together at various rates of speed, we understand the invention has worked well, and the prevention of going within the buffers to uncouple has also been shown to be advantageous. Certainly an invention which offers to save life and limb, to reduce expenditure both of time and money in working, and to lower the wear and tear of line and plant, deserves the attention of the railway world. The difficulties in the way of adopting an entirely new fitting to the railway plant of the kingdom are great, but we believe that were practical men convinced that the proper remedy had been found for what is an admitted defect there would be little time lost in procuring its universal adoption.—*Railway News.*

The Euphrates Valley Railway.—The "Madras Athenæum," referring to the proposed scheme of Mr. Andrew for constructing the Euphrates Valley line, and the improved prospects which it now offers, says:—"We see already the kind of traffic which will find its way through the Suez Canal. That canal is chiefly a rival to the old Cape route, besides developing a traffic peculiarly its own with the coast of Arabia and the ports of the Mediterranean and the Bosphorus. It is not as a route for mails, nor yet for passengers, that the Suez Canal is to succeed, but as a route for heavy goods. The routes by the Euphrates and by the Suez Canal would not be rivals, but auxiliaries, just as were the old Cape and overland routes. And if France has had cosmopolitan spirit enough to construct the one, surely England will not lag behind and neglect the other, the less expensive, the more certainly remunerative, the shorter and pleasanter road. The Suez Canal was, to all but genius itself, a fearful speculation. The Euphrates Valley Railway is a most promising work. It is simply a missing link in a vastly improved and economical chain of communications. It is not such a missing link as was the Suez Canal, which leads ships through a desert, but one which connects markets together more closely, virtually opens out new ones, and furnishes also a connecting link of races between the Reformers of the West and the Conservatives of

the East. How small that link is, compared with the whole chain of communication from London to Calcutta and from London to Madras, will surprise many whose attention has not recently been called to the matter. There is actually steam communication the whole distance with the exception of the journey, 550 miles long, from Bagdad through Aleppo and Antioch to Seleucia. The river journey from Bagdad to Bussorah, 300 miles, it is also proposed should be superseded by a railway. The Grand Trunk has granted a concession of this railway, a portion of which, from Seleucia to Aleppo, 90 miles, and the only portion presenting any engineering difficulties, has been thoroughly surveyed and examined with respect to the local traffic, and we are informed by the old advocate of this route, Mr W. P. Andrew, that reckoning its cost at £1,500,000, General Chesney, Sir John M'Neill and a commission of French and English, appointed by the Sublime Porte, reported that the existing goods traffic alone would pay 10 per cent. on the outlay. The estimated cost for the whole line of 850 miles is £8,500,000, and of the line between Bagdad and Seleucia £5,500,000, and of the section between Aleppo and Bagdad £4,000,000 —*Railway News.*

NEW ALARM SIGNALS FOR TRAINS.—M. Herremann has invented a new system of alarm signals applicable for day and night. The ordinary carriage lamp is replaced by a special one, which is lifted above the top of the carriage by a spring acted upon by a button within, while in the day time the same action shows a small flag; in either case a continual peal of bells is produced in aid of the other signals In case of the train being stopped at night by an accident all the lamps may be lifted up, and at once throw a light on the line, and form a signal of distress that would be visible at a considerable distance in the open way.

ORDNANCE AND NAVAL NOTES.

FETHI BULEND, OR THE GREAT VICTORY.—During the past week the new Turkish iron-clad corvette "Fethi Bulend," or the Great Victory, has been, by order of the Lords of the Admiralty, officially tried over the measured mile at the Maplin Sands, off Sheerness. The "Fethi Bulend" was built by the Thames Ironworks Company for the Sultan, from the designs of Mr. E. J. Reed, C. B., late Chief Constructor of the Royal Navy. She is the second vessel built from the same designs for the Turkish Government, and both are specimens of a class which Mr. Reed earnestly but fruitlessly pressed upon the attention of the Lords of the Admiralty. The "Fethi Bulend" is of about 1,600 tons burden, with a length between perpendiculars of 235 ft. and an extreme breadth of 38 ft. Her armament consists of four 12½-ton Armstrong guns (Woolwich pattern), and these are enclosed in a central battery, defended all round, and above, by the heaviest armor plating. The vital parts of the ship, such as the engine room boilers, magazines, etc., are protected by 9-in. armor plates, and the less vital parts by plates diminishing from 6 in. to 4 in thickness. All these plates are fixed upon the most substantial "backing." By an ingenious arrangement of the ports, aided by the tapering form of the hull fore and aft, each of the guns, in addition to broadside firing, can be fired in a direct line with the keel, actually commanding a range of from 90 to 95 degrees, and thus giving the ship immense advantages either in chasing an enemy or defending herself from a more powerful pursuer. Her engines are direct-acting horizontal, of 500-horse power nominal, by Messrs. Humphrys, Tennant, and Co. The cylinders are 88 in. in diameter, with a stroke of 3 ft. 3 in. Six runs at full boiler power were made over the measured mile, and a mean speed obtained of 14¼ knots, according to Admiralty calculations. The indicated horsepower was nearly 8½ times the nominal, the maximum number of revolutions being 87, the mean 84, vacuum 25. This highly satisfactory result was obtained with ordinary stokers, ship's coal, and at a most unfavorable state of the tide. The machinery worked in the most perfect manner from first to last, there not having been the slightest approach to overheated bearings. The propeller was a four-bladed Griffiths having a diameter of 16 ft. 6 in., and 19 ft. pitch. The ship, which certainly does not present a very handsome appearance afloat, is simply schooner-rigged, with 2 low masts, and the only presentable object above deck she offers for firing at from a distance is her funnel. It should be added that the "Fethi Bulend," like the "Achilles," is fitted with Rear-Admiral Inglefield's hydrostatic steering gear, by means of which the ship can be steered from almost any point below deck; so that, literally speaking, not a living soul need be exposed on the upper deck during an action.

THE GATLING AND THE MITRAILLEUR AT SHOEBURYNESS.—We extract from a lengthened account in "Engineering" of several days' experiments with a variety of ordnance, the following account of the closing trial of the series:

The Gatling gun and the French mitrailleur were on trial. These weapons were tried against the 12-pounder and 9-pounder field guns, at known ranges of 800 yds. in the marsh, before targets representing open columns of cavalry and infantry. The details of these experiments will be seen in the table. The targets were 3 rows of boarding, 45 ft. long, 9 ft. high, and placed at distances of 15 yds. behind each other. The 12-pounder gun fired segment shells fuzed with the E. O. C. percussion fuzes with safety pin and cap, as recently improved by Col. Milward, the gun charge being 1 lb. 8 oz. The second row of targeting suffered most severely. The mitrailleur practice was rather wild, the shots for the most part flying high and falling far in the rear of the targets. The practice with the small Gatling gun having 10 barrels of 0.42 in. calibre, was very unfortunate. Two stoppages occurred, which were caused by the front screw of the central bar being too tightly screwed up, and only a comparatively few rounds were got off. Few though they were, they did good work, and proved that the weapon possesses great destructive powers over the mitrailleur. It was stated that the gun had just been received in England; in fact, it only arrived on the ground on Tuesday morning, just before the visitors, and there had been no time to get it in proper order. The 9-pounder bronze gun was fired with shrapnel, fuzed with a new pattern fuze, purely experimental, and which did not answer, two rounds being premature, and one bursting behind the targets.

As we observed in our previous notice, the mitrailleur possesses all the elements of a useful weapon for special purposes in warfare. But it

requires further developing for speed before it can compete with the field guns firing shrapnel or segment shell. The results of the practice show, moreover, that these latter weapons will find a powerful rival in the Gatling gun, of which there are now three sizes at Shoeburyness. During an interval in the programme, the second sized Gatling gun was tried, with astounding results. It is supplied with cartridges by a feed drum revolving on a vertical axis over the firing chamber. The gun was laid at a target on the sands, and 400 rounds were fired in 58 seconds. The target was perfectly riddled, the line of aim having been rigidly maintained. This being the case, it only requires the application of the very nice automatic motion which Dr. Gatling has applied to his smallest gun—the one referred to in the table—for obtaining a continuous horizontal right and left traverse, to constitute a weapon which, subject to the chances of war, would prove to be superior to any other of its class extant. Although these experiments have thrown the mitrailleur somewhat in the shade for the present, they have at any rate developed and established the power of other resources which England has at her command should the hour of need ever come.

	Weapon.	Range in yds.	No of Rounds.	Elevation.	No. of hits.
1	* 12-pounder gun	800	6	1° 20′	496
2	† Mitrailleur	"	407	..	81
3	‡ Small Gatling gun	"	201	..	82
4	§ 9-pounder gun	"	7	..	254

* Segment shell. Seventh round in gun.
† Shots all very high, mostly over. Another plate ready in gun.
‡ Gun not in working order.
§ Experimental fuzes used, which failed.

A RETURN prepared at the War Office shows that since the adoption of the Snider breech-loading principle 459,553 breech-loading infantry rifles have been produced in this country, the great majority by the conversion of muzzle-loading rifles, and 123,979 carbines and muskets of other descriptions have been produced, also chiefly by conversion, making a total of 583,532 breech-loaders. On August 8, there were 192,362 breech-loading rifles and carbines in possession of the regular and reserve forces, without including the arms supplied to the navy, the Indian Government, or Colonial Governments. On August 8, there were 300,923 breech-loading rifles of all descriptions in store; 247,740 were in the hands of store-keepers at home stations, and 53,183 at foreign stations, excluding India. Regiments have left this country for India armed with 10,956 Snider breech-loaders. Another return relating to rifled guns states the number (the date is a year ago) of serviceable rifled guns to be 5,325, viz., 1,723 muzzle-loading and 3,602 breech-loading; 586 have been fitted and issued for land service, and 1,778 for sea service, and the other 2,961 require no change in the sights to make them available for either service, but simply the addition of a guide plate and crutch, or pin friction, to use them for sea service, and the guns and vents are prepared to receive these fittings; and the whole of the 5,325 guns are available for either land or sea service, the fittings being supplied as required. The return gives a full account of these guns—their class, weight, charges, penetrating power, average endurance, ranges (the highest is 6,915 yds.), and cost, which may run up to more than £2,300. The return goes on to state that the fortifications, as designed, will require 898 large rifled guns and 1,031 guns of 95 cwt. or under. The existing plant of the Royal gun factories is stated to be capable of producing 500 tons of guns of various calibre per month. The time required for the manufacture of wrought-iron muzzle-loading rifled guns is stated as one week for each inch of calibre; thus, a 7-inch gun requires about seven weeks to manufacture it up to proof. This assumes that the guns are being made in numbers, and the factory is well employed (a single gun could not be manufactured in the time named), and that they are of natures of which we already have patterns. A third return, dated August, 1870, states that there are at home 30 field and horse artillery batteries; but they would require a considerable addition to their establishment of horses and men for the wagons requisite on taking the field, but which are not necessary to be maintained in time of peace. The number of field guns in store is given as follows:—Of 20-pounders, 16 cwt., 65, and of these 8 batteries of 6 guns each are complete with carriages; of 12-pounders, BL., 8 cwt., 173; and of 9-pounders, 6 cwt., 60, and of these 14 batteries of 6 guns each are complete with carriages: of 6-pounders, 3 cwt., 14. 10,000 single sets of artillery harness and 3,000 of transport harness are in store.—*Mechanics' Magazine.*

CONSUMPTION OF COAL ON BOARD HER MAJESTY'S SHIPS.—The Admiralty have issued a circular (No. 62 N. S.) consolidating all general orders given on the above subject. The mixture of Welsh (or non-bituminous) with North-Country (or bituminous) coal is to be vigilantly enforced in all her Majesty's ships, the necessary alterations having been made in the furnaces for burning mixed coal. These coals are to be supplied to her Majesty's ships in the following proportions:—"For royal yachts, a special supply of Nixon's navigation steam coal will be obtained; for trials at the measured mile, and at the six hours' trial at sea, good hand-picked Welsh coal of any of the following descriptions, viz.: Ynys-faio Merthyr, Davis' Merthyr, Ferndale, Powell's Duffryn, Sqwborwen Merthyr, Fothergill's Aberdare, or Nixon's navigation should be used. The officers conducting the trials are always to report on the trial forms, No. 353, in the place provided for the same on the first page, the description of the coal used, and in the third page in the remarks its qualities as regards—(1) the generation of steam; (2) the emission of smoke; (3) the consumption of fuel; (4) the percentage of ash and clinker. Ships and vessels in the Channel squadron, and on the home station (and in the Mediterranean, if their furnaces have been altered), are to burn one-half Welsh, or non-bituminous, and one-half North-Country, or bituminous, coal; if the furnaces of any ships in the Mediterranean have not been altered, they are to burn two-thirds Welsh and one-third North-Country. All other ships and vessels are to burn two-thirds Welsh, or non-bituminous, and one-third North-Country, or bituminous." With respect to *economy in the use of coal*, the following are the directions given:—"As

a general rule, all ordinary passages and all cruising under steam, except for special steam tactics, are to be performed at rates of speed between four and five knots. No ship, unless ordered to be at a given port by a given date, or unless her safety would be endangered by observing this rule, is ever to steam when she has a fair wind capable of sending her between four and five knots, or when she has a foul wind sufficiently strong to prevent her carrying royals, unless when going in or out of harbor. The maximum supply of coal is to be limited, and the best speed obtainable at that limitation is to be strictly enforced on all ordinary occasions, as follows: For ships which have engines of from 1,200 to 1,350-horse power, the maximum consumption is to be limited to 25 cwt. per hour; for ships which have engines of 1,000-horse power, but less than 1,200, the maximum consumption is to be limited to 20 cwt. per hour; for ships of 800 and less than 1,000-horse power, the consumption is to be limited to 22 cwt. per hour; for ships of 500 and less than 800-horse power, the maximum consumption is to be limited to 18 cwt. per hour. The consumption of smaller ships is to be limited in the same proportion. If a speed of between four and five knots can be obtained by a smaller consumption of fuel than the maximum allowance, it will be the duty of the Commander-in-Chief to enforce the smaller consumption on all ordinary occasions of steaming. When ships have a fair wind, and are using steam, the consumption of coal ought to be reduced; whenever it is allowed, as it often is, to increase, the coal is being wastefully burnt. These instructions are not intended to limit the discretion necessarily given to officers in cases of emergency, but they are to be strictly complied with on all ordinary occasions. These limits of speed and consumption of fuel are not applicable to her Majesty's troop-ships while employed on the Indian overland troop service, or in emergency; but on all ordinary occasions while troops are on board, the speed under steam only is not to be greater than nine knots an hour. At all other times the strictest economy, compatible with the nature of the service, is to be observed in the consumption of coal."

A MAGNIFICENT four-decker mail steamship has been launched on the Clyde recently, for Burns and M'Iver's Atlantic Mail Service. She was named the "Parthia," is upwards of 3,000 tons, and will accommodate about 1,200 passengers in addition to her crew. The "Parthia" is one of four vessels of similar capacity which this firm intend adding to their present fleet, and which will not be excelled by the steamers of any other company in the world. A new steamer of 2,240 tons was launched recently for the North-German Lloyd's Steam Packet Service, and was named the "Prinz" as she glided off the stocks.

ENGINEERING STRUCTURES.

ISTHMIAN RAILROAD ENTERPRISES. Mr. Henry Stuckle, a French engineer of high standing, who until lately filled the office of general superintendent of the Alsacian railroads, and who is known to American engineers as the author of "Voies de communication aux Etats Unis," has just published a valuable work upon inter-oceanic transit, which contains some interesting information upon existing and proposed routes of transit across the several narrow isthmuses which unite the American continents. From the mass of valuable information with which the volume is filled, we gather a few facts of interest respecting the railroad enterprises already under construction, which are designed to meet, so far as it can be met by anything less than a ship canal, the necessity for improved facilities for transportation between the two oceans. Of these enterprises three are already under way, the most important of which is the road now building across the Isthmus of Tehuantepec, under a concession obtained from the Mexican Government in January, 1869; and there is every prospect that within a comparatively short time this road will be in actual operation. For many reasons, the Isthmus of Tehuantepec is the most favorable point for the establishment of inter-oceanic communication, whether considered merely with reference to the commerce of this country alone or to that of Europe and the Oriental countries. From Europe, or the Eastern coast of the United States, to the Pacific, it is the shortest practicable route, excepting that of the Pacific railroad, the limited utility of which for the transportation of trans-continental freight has been already demonstrated. As compared with Panama, the Tehuantepec route possesses many important advantages, of which the most important is the saving of distance and time by following the latter, as is shown by the following table showing the length of a voyage to San Francisco from the points named:

	Via Panama.	Via Tehuantepec.	Saving via Tehuantepec.
Liverpool	8,507	7,416	1,131
New York	6,218	4,741	1,477
New Orleans	5,718	3,384	2,334

This line, which will be pushed to completion without unnecessary delay, starts from a point near the mouth of the river Goatzacoalcos, and extends westward to the Pacific. The harbors at both ends of the line are said to be the finest on the coast of Central America—an advantage which cannot be claimed for Panama; and there is every reason to believe that the road will command a profitable traffic in inter-oceanic freights, both American and foreign.

Beside this enterprise, which is entirely in the hands of American capitalists, roads are building across Honduras and Costa Rica. These, however, are regarded as of more importance to the development of the country traversed by them than as affecting the course of inter-oceanic freights. These two isthmuses, situated between Tehuantepec on the North, and Darien on the South, are not favorably located to command any considerable share of the inter-oceanic traffic. The Honduras road, lying some 500 miles south of Tehuantepec, can not present equal advantages with the latter, and the Costa Rica road, lying within 200 miles of the Panama road, is, for many reasons, unable to meet the condition which American commerce demands of an isthmian transit route. The same conditions which determine the relative utility of these competing

railroad lines, will be found to apply with equal force to the much discussed inter-oceanic canal, when our capitalists are ready to undertake that work. Darien would be the most favorable point at which such an enterprise might be located, if it were possible to pierce the unbroken ridge of the Cordilleras at any point where enough water could be procured to fill the upper levels; but since Darien must be abandoned as impracticable, for the reasons which we gave at length when the project was first seriously discussed by our capitalists, Tehuantepec is the only route which can be followed with advantage to American commerce. A canal at this point would cost more than that proposed at Nicaragua, but the saving of distance over a more southerly route is an important item, and this, with certain topographical advantages, gives Tehuantepec the preference. Two marked features distinguish the topography of Tehuantepec. The first is the depression in the Cordilleras at that point precisely where the isthmus is the narrowest, as if nature herself had desired to facilitate the opening of a water route from sea to sea. The second is the number of large rivers draining the slopes of the mountains on either side of which the most important is the Goatzacoalcos and its tributaries. Another remarkable circumstance is, that the courses of the rivers in general are in a marvellous degree favorable to the formation of a water way across the isthmus, and that at the summit of the mountainous region, where the waters are divided and flow down on either slope, there exists an abundant supply of water to feed the summit level of a canal. These features of Tehuantepec are worthy of the attention of the Government, and we are glad to learn that the expedition which sails on the 5th of October, under command of Captain R. W. Schufeldt, will make surveys both of this isthmus and of Nicaragua. An impartial report from an intelligent Government officer, based upon actual surveys, would do much to establish public confidence in the practicability of whatever route may be finally adopted; and if it shall facilitate the opening of inter-oceanic communication, the appropriation of small sums for explorations and surveys will be found a judicious measure of public economy.—*Iron Age.*

Submarine Telegraphs to the East.—The Telegraph Construction and Maintenance Company have despatched to the East the last instalment of the cables belonging to the British-Indian Extension Telegraph Company, and a section of those for the British-Australian Telegraph Company. The steamship Hiberma sailed for Batavia on the 23d July last with the section to be laid between that port and Singapore. The steamship Edinburgh left on the 21st ult. for Penang, *via* the Cape of Good Hope, with the section to be laid between that point and Madras; and the steamships Scanderia and William Cory sailed from the Thames on the 7th instant, bound for Singapore, *via* the Suez Canal, with the heavy cable for the Straits of Malacca. The officers and engineers, with the necessary staff, have already proceeded to their respective stations. The submergence of the total length of upwards of 2,400 nautical miles of these cables will commence from Batavia to Singapore, and thence to Madras; and all the requisite arrangements have been made for these contracts being carried out by Christmas-day next. By that time we may safely anticipate that the Eastern Archipelago will be brought into telegraphic communication, with the present system of submarine cables working so admirably from Falmouth, *via* Gibraltar and Malta, with British India. The manufacture of the China cable, the last of the series, is proceeding rapidly at the Telegraph Construction Company's works, and the arrangements for laying it in the early part of 1871 are completed.

The West India Telegraph Cable.—Despatches from Cuba state that the laying of the West India Cable had been so far attended with several mishaps. The steamer Suffolk having laid the shallow water cable between Batabano and Key Diego Perez, the Dacia, with Sir Charles Bright on board, was to lay the deep sea cable. Two faults were, however, discovered and the Suffolk was sent to repair the damage. The first fault was found to proceed from a defect in the construction of the cable, and the second was caused by the dragging of an anchor. On the 12th ult. the Dacia was able to commence immersing the deep sea cable, but she had only proceeded four miles when the cable became entangled on a sudmerged rock, and broke. The cable was again taken up, spliced, and relaid, and the Dacia continued her voyage; but five miles further on the depth of water suddenly changed from 11 fathoms to 200 fathoms, and the cable again parted. The immersed portion was again grappled, but just then it was discovered that another very serious fault existed in the cable between Batabano and Key Diego Perez, at some 40 miles from the former place. Sir Charles Bright thereupon buoyed the grappled end, and returned to repair the discovered fault, and this he was engaged doing when last heard from.

The "Times" of September 14, says:—"The West India Cable has been successfully laid between Batabano and Santiago de Cuba, a distance of about 400 miles. Batabano is 35 miles from Havannah, on the southern coast of the island, and Santiago is near its south-eastern end, the cable having been laid from the former to the latter. This success removes a load from the minds of the electricians. According to the latest letters from the cable fleet, apprehensions, were felt as to the practicability of laying the cable in channels so filled with boulders and coral reefs as those on the Cuban coasts. Repeated accidents were happening from those causes, and they were of so serious a nature that it was even proposed to change the route. Success has, however, ended these troubles, and at Santiago there has been much rejoicing. On the night of the 27th of August the harbor was illuminated; there was a display of fireworks and a torchlight procession in boats. Sir Charles Bright was serenaded by a large party, who, chartering 7 steamers, sailed around the vessels of the expedition. Count Valmaseda visited the Dacia, which, with the other vessels, was illuminated. The cable is reported as working finely."

A Suspended Tunnel in the Bosphorus.—The enormous traffic from the Stamboul to the Galata and Pera side of the Bosphorus, a continuous stream from morning to night, interrupted only

by the vexations and delays caused by repeated openings and shuttings of the bridges of boats which constitute the connecting line of the two shores, must be considered as a sure indication of the utility and necessity of an uninterrupted communication between the two banks.

A tramway company of ample means has lately started with the intention of transporting both passengers and goods on their various lines, both constructed and constructing on either side of the Bosphorus; but little real profit can be expected to be made till the lines on either side are connected together.

The existing bridges of boats are barely large enough for passengers, so that permission cannot be obtained by the Company to lay down their rails thereon, besides which the constant interruptions would be highly prejudical. The enormous depths of the water, the precipitous banks, and the well-known twenty or thirty feet of mud which forms the bottom, quite forbid the idea of tunnelling in the ordinary way, it being impossible to get down low enough, even with the stiffest gradients. One of the chief engineers of the Turkish Government (Mr. Hadden) has therefore suggested a very simple yet effective mode of overcoming these difficulties.

He proposes to suspend or float a tunnel at about 35 ft. below the surface of the water, allowing uninterrupted passage to vessels of the largest tonnage. There is no tide in the Golden Horn. The tunnel would consist of a wrought iron tube, about 10 ft. in diameter, and 1,200 ft. long; the tube to be cellular, and each cell perfectly independent, or the tube may be lined with wood. The gradient at either end would be one in fifty.

The tube will weigh about 600 tons; maximum weight of any train 400 tons; concrete and lining, to overcome the buoyancy of the tube, 1,700 tons; water displacement, 2,700 tons.

It will be readily seen that when the tunnel is unused there will be a buoyancy or upward strain of 400 tons, which is to be neutralized by holding down chains, which will act precisely like inverted piers or supports. When a train traverses the tunnel, if of less weight than 400 tons, it is evident that no deflection can take place; and on the train leaving the tunnel the chains prevent the reaction of upward deflection which would without their holding-down power naturally ensue. In the drawing the tunnel is represented as held down at only *three* points, but any number may be used. It is proposed to name the tunnel "Daoud," after the present talented Minister of Public Works, Daoud Pacha.—*The Engineer.*

NEW SMOKE-PREVENTING BOILERS.—An important invention has just been patented by Mr. Arnold, of Barnsley, and Mr Carnelly, of Manchester, by which a boiler is so constructed that by a peculiar arrangement of the flues no smoke is emitted into the chimney. The invention has just been tested at the works of Jackson Brothers, of Barnsley, and with such success that whilst the smoke was thoroughly consumed there was a saving in fuel of nearly one-third, as compared with the ordinary boilers, whilst imposing no additional labor on the fireman. The patent boiler has two self-contained fire-boxes or furnaces, and instead of a bridge, as in an ordinary two-flued boiler, there is placed a stoppage or end to the fire-box, by which the flame or draught is arrested in its usual course, and conducted through two transverse openings – one on each side of the fire-box. The gases that are evolved are caused to pass through the openings named underneath the boiler into what is termed a combusting chamber, where the incandescent gases ignite into a flame of intense heat and brightness, thus preventing the formation of smoke, seeing that it is an admitted and well-known fact that when smoke is once formed it is impossible to burn it, though it should pass through a white heat. From the combusting chamber the flame is conducted into a second tube chamber, where are inserted a number of what are called Arnold's vertical tubes of 3 in. lap-welded. The fire-box and back flues are separated by a water-space, and those being self-contained give great strength to the boiler, and render the collapsing of the tubes almost impossible; also, in consequence of the old bridge being done away with, a greater amount of heating surface is obtained from the same amount of fuel. The immense heating surface obtained by the thorough burning of the carbon confirms the calculations of MM. Farre and Silberman, who completed the researches of Dulong. They found from their experiments that the pound of carbon imperfectly burned, producing carbonic oxide, gave 44,000 units of heat, whereas one pound of carbon entering into complete combustion, producing carbonic acid, gives 14,500 units of heat.

The principles embodied in the new boiler are those which have been advocated by all the most celebrated engineers and chemists of the last 20 years, but have never been carried out in their full entirety until now. Of the other advantages claimed by the patentees are that the working of it requires no extra care in firing, for the most careless stoker would fail to create a nuisance in the production of smoke. The invention, which can be applied to any existing boiler, either Cornish or cylinder, combines simplicity, efficiency, strength, and economy; is self-acting, and not liable to get out of order. Practical men, who have witnessed the working of the new boiler and apparatus, are unanimous in the opinion that the invention is a valuable one, and will, no doubt, be pretty generally adopted.—*The Mining Journal.*

NEW BOOKS.

ARCHITECTURAL IRON CONSTRUCTION. By W. & T. PHILLIPS. 1870. For sale by Van Nostrand.

This little work, the first of a series, ought perhaps rather to be called a "Handy-book upon the Use of Wrought Iron," as its object is not so much to propound any new theory, or to introduce any new formula, as to methodize and apply in a practical and accessible manner the results and deductions of other larger and more elaborate works on the strength of materials and the theory of strains.

The work, when complete, will consist of five parts 1. Beams and Girders, the pamphlet before us. 2 Fire-proof Floors. 3. Roofs. 4. Buildings. 5. Bridges.

The first part, now published, commences by comparing the various formulæ for timber, flitch beams, cast-iron beams, riveted beams, calling attention to Phillips's Patent, and finally dealing with beams of homogeneous rolled wrought iron. The formulæ are quoted *in extenso* in each case, and some examples are given showing the com-

parative cost, strength for strength, of the different materials. Lattice girders have also a special formula adapted for them, and the various advantages attending their use in certain situations are clearly pointed out and illustrated by the plate.

A valuable part of the book will be found on page 17, which contains a table showing the safe distributed load in tons, etc., for clear spans or bearings, from 7 ft. to 40 ft. in the clear, of solid rolled girders, varying in depth from 4 in to 12 in.

Given the weight to be carried and the bearing in the clear, a reference to this table will at once give the requisite section, large or small, of wrought iron required to do the work, and its weight per foot run.

To the educated and practised engineer the work is no more than a handy book of reference, but we cannot help thinking that, though really a trade book, it embodies in a concise and accessible form information that will be valuable to architects and builders, in regard to its subject matter.

INTEROCEANIC CANALS, an Essay on the Question of Location for a Ship Canal across the American Continent. By HENRY STUCKLE, late Superintendent of the Alsacian Railroads. New York: D. Van Nostrand; London: B. F. Stevens; Paris: E. Dentu.

This book of 140 pages presents the following subjects in their order: Present state of interoceanic communication in America; the Suez Canal and the proposed American ship canal; the problem to be solved by an American ship canal; the most advantageous location with reference to the interests of the United States.

The last chapter is the most valuable of the series, as it presents an epitome of the advantages afforded by the Tehuantepec route, in which the results of former surveys and estimates are carefully summed up.

Three maps illustrate the text.

THE NEW ELEMENTS OF HANDRAILING. By ROBERT RIDDELL. Philadelphia: Claxton, Remsen & Haffelfinger. London: Trubner & Co., Paternoster Row. For sale by Van Nostrand.

In conclusion, we can cordially and safely recommend "The New elements of Handrailing" to the sober attention of the building mechanics of this country. To one and all it will be found most useful. It dispenses with useless lines, simplifies the method, places everything clear to the understanding, bases construction on unerring scientific principles, and thus it is a valuable medium and auxiliary in the technical education and moulding of the skilful and practical workman.—*The Builder.*

TABULATED WEIGHTS OF ANGLE, T, BULB, BEAM, ROUND, SQUARE, AED FLAT IRON, FOR THE USE OF NAVAL ARCHITECTS AND SHIPBUILDERS. By CHAS. H. JORDAN, M. I. N. A. London: E. & F. N. Spon, 48 Charing Cross. 1870. For sale by Van Nostrand.

One of the most useful little books that an engineer can possibly have in his office is "Penn's Tables." But Penn, unfortunately, goes no farther than bars and plates. He does not touch upon angle, T, channel, H. or any other section of iron that is peculiarly well adapted for the resistance of strains of compression. Mr. Jordan endeavors in the half dozen pages composing his publication to supply the information not to be found in the tables of Penn. The manner in which he has chosen to accomplish his task is scarcely so happy as it might have been. Every draughtsman who has had to make an estimate of an iron bridge, roof, or other structure of that material, in which angle iron is certain to enter as one of the principal forms, knows how to calculate the weight of that form of section. Briefly, the angle iron is treated as a plain bar. The sum of the sides, minus the thickness, reduces the angle iron at once to a bar equal to that breadth, and of the same thickness. This is nearly the course followed by Mr. Jordan; whereas, for the tables to have been of real utility in the office, the dimensions of the different sections should have been given. In fact, Mr. Jordan's tables do not give us the weight of any angle iron, but the weight of a bar equivalent to it in sectional area. This is not what is wanted. For example, take an angle iron 3½ in. by 3 in. by ½ in.; this is equivalent to a bar 6 in. by ½ in., which weighs 10 lbs. The sum of the sides is equal to 6½ in. Consequently if we turn to Mr. Jordan's tables we shall find that the breadth of flanges 6½ in. by ½ in. also weighs 10 lb. But the real labor to be saved is the adding together of the flanges, and as these half dozen pages do not save that labor, they have done little or nothing towards facilitating the calculation of the weights of different sections of iron. Tables that pretend to give the weights of angle irons should enter them with the proper dimensions, that is, with the breadth of each flange in a separate column. An angle iron 3 in. by 4 in. should read in the tables 3 in. by 4 in., and not 7 in. If this were done in a revised edition, the little book would be of much value. The labor would be nothing, as the present calculated weights would all stand as they are. At present, Penn's tables supply all that Jordan's profess to do.—*Engineering.*

RESEARCHES ON THE ACTION OF THE BLAST FURNACE. By CHARLES SCHINZ. Translated from the German, with the special permission of the author, by WM. H. MAW and MORITZ MULLER. London: E. & F. N. Spon. For sale by Van Nostrand.

The author is not a metallurgist, but, as he explains in his preface, being ardently devoted to the art of measuring heat, and applying it rationally in the various branches of industry, he naturally made the manufacture of iron an object of study.

His published papers have been widely copied by leading scientific papers in Europe and America.

Aside from the value which the present work bears to the iron worker, it presents to the practical chemist an excellent model for method of investigation in many other processes in which combustion plays an important part.

PEWTNER'S COMPREHENSIVE SPECIFIER.—A Guide to the Practical Specification of every Kind of Building Artificers' Work. Edited by WILLIAM YOUNG, Architect. London: Longmans, Green, and Co. 1870. For sale by Van Nostrand.

This book is addressed to the student, to the builder, and to the architect. To the student, as a manual by which he can become familiarized with the technicalities of the profession to which he is devoting himself, with all the various requirements met with in its practice, and the method in which instructions from the architect are given to the contractor. For the builder and architect the

volume is intended as a manual which shall not be found wanting in supplying information respecting building work in all its details; and to render it more valuable especially to the two latter classes, a complete and well arranged index is added. There are 694 clauses in the book, of which 637 are devoted to general specifications, and the remainder to conditions in compliance with which the works particularized in the previous portion of the volume are to be executed.

As a rule, we have found that such compilations as Mr. Pewtner's are very far from satisfactory, or even useful, for they contain those things they ought not to contain, and omit those things which they ought to contain, a failing discouraging in itself, and likely to produce mistrust of all other similar publications. To a considerable extent, however, this standard fault of such volumes of reference has been avoided in Mr. Pewtner's book, and the catalogue and description refer to almost every conceivable subject connected with the architect's and builder's business.

The book is well classified, and the main object at which it aimed has been, we think, successfully attained, that of giving in as few words as possible the necessary amount of information upon each subject treated, which is rendered in concise terms, always an advantage in drawing up a specification. We recommend the volume to architects, builders, and students, the three classes to whom it is addressed, believing that they will find it valuable for reference, and that it will frequently be the means of saving valuable time.

LA DYNAMITE, SUBSTANCE EXPLOSIVE. Inventée par M. A. NOBEL. Collection de documents rassemblée, par PAUL BARBE. Paris, 1867.

LES GRANDES USINES: Etudes Industrielles en France et a l'Etranger. Par TURGAN. Paris, Michel Leray Freres.

These beautiful volumes, as they appear in succession (one each year), fulfil the promise of the first issue, which appeared in 1863. They are of royal octavo size, and contain about 350 pages each. The metallurgical and chemical manufactures are beautifully illustrated, the cuts extending across two pages in order to represent an entire interior of a factory on a scale sufficient to exhibit the details of the process, or in many instances of the machines.

The typography and illustrations are of the same quality as "La Vie Souterraine," and "Guillemin's Heavens."

8 vols. from 1863 to 1869 inclusive. For sale by Van Nostrand.

MISCELLANEOUS

LEAD SMELTING FURNACES.—Reference was made in the Journal of August 27 to an improved furnace, invented by Mr. George Metcalf, of the Petusola Foundry, near Spezia, Italy, and in successful operation there; it is now proposed to give a brief description of the invention itself the object of which is to expedite and facilitate the operation of obtaining lead from its ores. For this purpose a furnace is used divided longitudinally for a portion of its length by a vertical partition or wall extending upward to the crown of the furnace, but not extending to the grate or fire-bars, so that a chamber with a bed is left near the grate or fire-bars extending the entire breadth of the furnace, and having no partition at that part. The compartments formed by the partition have at their ends arrangements for opening and closing communication between them, and ducts or uptakes leading thence into the chimney. The charges are placed in the compartments formed by the partition, and are gradually fed forward to the fire chamber or bed in front of the fire-bars. The draught is shut off from each compartment alternately, one compartment being open to the chimney, while the other is closed, so that while one set of charges are exposed to the free current of flame, or aeriform or gaseous products of combustion rushing from the fire through the compartment towards the chimney, the other set of charges are subjected only to the action of dead heat, because the draught apertures at the end are closed. The lead as it is fed in dries and becomes calcined, and wholly or partially desulphurized, as it is passed gradually along the chamber, and at length it reaches the bed or chamber in front of the fire-bars. The greatest portion is then removed, in a state of slag or agglomeration, through an opening in the furnace, fitted when opened, with a removable spout down which the slag descends into a wagon, and is run off therein to a blast-furnace, in order to be again subjected to heat for metallurgical purposes.

The advantage claimed for Mr. Metcalf's furnace is that less heat is required, and consequently less fuel is expended, and the furnace is better preserved. The lead that remains in the furnace is removed by tapping the furnace, and allowing the molten lead to run out. The bed of the furnace is by preference constructed of a peculiar curved form, and in order to get out all the lead, in case of the furnace bed leaking or becoming destroyed, a false door is used parallel with the tapping-door and screwed thereto, the interval between the two doors or plates being filled with bone-ash, or other non-conducting material. Thus, if the furnace-bed gets destroyed or leaks, and the lead runs through it, the lead or metallic product can be withdrawn through the false door. The novelties claimed for the invention are the employment of the partition extending for a portion of the length of the furnace, so as to form two passages as already, the employment of the two tapping-doors, and the general arrangement of the parts.

It will readily be understood that, as already stated, four charges are continually under treatment - two on the preliminary side of the partition, and two on the finishing side. These charges average 1½ ton of ore, and as one charge is drawn every six hours, it follows that each charge is 24 hours in the furnace. The result of the treatment is declared by competent judges to be as near as may be perfect. The loss by volatilization is much less than usual, and the saving of fuel is enormous, 5 tons with the new furnace doing quite as much work as 26 or 28 tons with the old reverberatory furnace. The wear and tear of material and plant is reduced by two-thirds, and the manual labor is certainly not greater than under the old systems, and is much more simple. The more favorable results obtained with Mr. Metcalf's furnace is accounted for by the fact that by its use, instead of burning the lead (thereby producing smoke and vapor), the lead is, by not being brought under the action of heat so intense as in the old systems,

not volatilized or oxidized, but simply metallized. The invention is generally considered one of the most important yet introduced.—*Mining Journal.*

THE Folkestone-Boulogne cable has been repaired and is now working. No private messages can now be received for Paris itself, but for Italy and the South of France the communication is still open.

It is stated that the company for the submersion of a new cable between this country and the United States will be brought forward directly after the conclusion of the war between France and Germany, as well as many other new undertakings which for the time remain in abeyance.

The China Submarine Telegraph Company have notified a postponement of the payment of the remaining capital, and that the same will now be payable in six instalments of £1, commencing on the 1st of October, and continuing each month till the 1st of March. This will not affect the laying of the cable by the 30th of June, 1871, the time fixed by the contract.

The St. Pierre-Duxbury section of the French Transatlantic cable, which was broken in May last, has been successfully repaired by the Joint Anglo and French Company's maintenance steamer Robert Lowe, Captain James Blacklock. Communication by all three cables of the Joint Atlantic Companies between London and New York is thus completely re-established.

The Government are giving evidence of their intention to increase the telegraphic communication between Great Britain and Ireland. The steamship Monarch and the powerful tug-steamer Blazer have arrived in Donaghadee harbor, county Down, having on board a telegraph cable and all the necessary apparatus for its submersion between Donaghadee and Portpatrick. It is to be laid alongside the cable which at present crosses at that point. In consequence of the severe weather the Monarch and the Blazer could not start on Tuesday upon their voyage, but as soon as the storm subsided the paying out was to commence.

The Telegraph Construction and Maintenance Company have despatched to the East the last instalment of the cable belonging to the British Indian Extension Telegraph Company, and a section of those of the British Australian Company. The screw steamer Hibernia sailed for Batavia on the 28th of July last with the section to be laid between that port and Singapore. The screw steamer Edinburgh left on the 21st ult, for Penang, *via* the Cape of Good Hope, with the section to be laid between that port and Madras, and the screw steamer Scanderia and William Cory sailed from the Thames, bound for Singapore, *via* the Suez Canal, on the 7th inst., with the heavy cable for the Straits of Malacca. The submergence of a total length of upwards of 2,400 nautical miles of these cables will commence from Batavia to Singapore, and thence to Madras, and all the requisite arrangements have been made for these contracts being completed by Christmas Day.

The West India Cable has been successfully laid between Batabano and Santiago de Cuba, a distance of about 400 miles. Batabano is 35 miles from Havannah, on the southern coast of the island, and Santiago is near its south-eastern end, the cable having been laid from the former to the latter. Apprehensions were felt during the work as to the practicability of laying the cable in channels so filled with boulders and coral reefs as those on the Cuban coasts. Repeated accidents happened from those causes, and they were of so serious a nature that it was even proposed to change the route. Success, however, has ended these troubles, and at Santiago there has been much rejoicing. On the night of the 27th of August the harbor was illuminated; there was a display of fireworks and a torch-light procession in boats. Sir Charles Bright was serenaded by a large party, who, chartering seven steamers, sailed around the vessels of the expedition. Count Valmaseda visited the Dacia, which, with the other vessels, was illuminated. The cable is reported as working well.—*Railway News.*

LEATHER PAPER IN JAPAN.—One of the most interesting and peculiar productions of paper is that which is made to imitate leather. The surface has every appearance of a finished skin, with extraordinary firmness and elasticity, and it can be subjected to washing without any injury from the water. These peculiarities are not so much due to the superior quality of the material, as to the mode of manufacture, the surfaces remaining intact, even when the paper is very thick, while with us paper of this kind soon loses its firmness, and the grain is impaired.

Japanese leather paper is made extensively at Flangawa, near Yeddo. It is made in sheets of 60 centimetres in length and 42 centimetres in width. The paper out of which it is prepared is not dissimilar to our packing paper, and is made in Southern Japan, near Nagasaki, and thence taken to other provinces, where it is manufactured into the different forms for various uses. The leather paper is made in the following manner: It is dampened and laid in pairs between two peculiarly prepared forms, made of paper also, only more highly varnished than ordinary leather paper; they have a very strong surface coating, but running only in one direction.

Before putting the paper in these forms, the sheets are stretched a little in the direction of their width. If there are several sheets, they are rolled on a cylindrical piece of wood, the grain of the paper running in an opposite direction from that of the wood; they are then unrolled from this on a cloth to keep them in shape, and put into a form with a hole in the top large enough to admit the end of the wooden cylinder. The roll of paper is then subjected to a pressure of 200 or 300 lbs. After the roll has been reduced to three-quarters of its original length by this pressure, it is taken out of the press and turned, the folds flattened out and again pressed, to remove the deep marks.

After passing the paper through rollers several times, the upper surface acquires the appearance of leather; it is then colored, oiled with a kind of rape seed oil, varnished, put once more in the press, which completes it, with the exception of drying. By means of parallel or cross lines on the rollers, the upper surface of the paper is made to resemble leather exactly in all its varieties. The paper being pressed to one-third, or even to one-half its original thickness, and the passage through the rollers giving it a fine-grained appearance, makes it valuable to picture printers, as the surface has the appearance of crepe silk.

There is another variety of leather paper which is smooth and transparent, resembling hog-skin very much. This is manufactured by a process of hammering, and is the highest priced, costing 27 cents per sheet, while the other ranges from 8 to

14 cents, some very fine selling at 8 cents per sheet.—*Journal of Applied Chemistry.*

POISONOUS LEAD PIPES.—We have recently heard, says the "Architect," of two or three very serious cases of lead poisoning arising from the use of lead cisterns and lead pipes for storing and conveying water. It seems strange that the old-fashioned lead pipe should continue to be used when a lead-encased block tin pipe, possessing all the good qualities of leaden pipe (such, for instance, as strength, ductility, durability, and cheapness), and having none of its objections, has been before the public for some time past. We allude to Haines's patent lead-encased block tin pipe, which is being supplied at the current market price of ordinary lead pipe of similar bore. With reference to the strength of the block tin pipes we have seen the result of some experiments recently made by Mr. Kirkaldy, which prove to demonstration that the bursting strain of the lead-encased tin pipe is nearly 50 per cent. greater than that of the ordinary lead pipe; and it has also been discovered as the result of experiments made recently at the offices of the Glasgow Waterworks, that the cohesive strength of block tin pipe was considerably more than double that of ordinary lead pipe. The same result was subsequently arrived at from experiments made at the Liverpool Waterworks, so that we have conclusive evidence that Haines's pipe is much more capable of resisting the expansive action of frozen water than the common lead pipe. Our readers would probably be interested to know the process of manufacture. A hollow cylinder of lead is cast; at the moment of hardening, and before it is completely cooled, a mandrel, equal in dimensions to the contemplated bore of the pipe, is inserted, and the space filled up with tin in a state of fusion. When the ingot thus prepared is nearly cool it is placed in a hydraulic press planned to receive it, and the pipe is forced through by mechanical pressure, which being applied equally over the interior and exterior surfaces, the homogeneity of the metal is perfectly sustained throughout. The average length of pipe thus obtained without a flaw is about 150 ft. As the pipe is running through the press it is carefully watched, and the instant an irregularity in the surface is observed the length is cut off. The tin lining must, of necessity, be perfect throughout, for the moment the tin ceases to draw, a wave or irregularity is observed in the lead, and the pipe is at once removed.

We are informed that the men are very careful not to allow any pipe to pass out of the press with a flaw, as the terms of their contract with their employer provide that if there is discovered, when the inspection is made before the pipe is put in stock, the slightest flaw in a length of pipe, the men are not paid for its manufacture. It will readily be seen that as tin melts at a lower temperature than lead some difficulty would arise in soldering. But this is easily obviated by the employment of a solder of which cadmium forms a sixth part. We are informed that the manufacturers are about to supply a solder made in the proper proportions.

Other attempts have been made at various times to coat lead with tin, but with very little good result. Tin has been applied by the electro-plating process, and by the more general method of drawing the leaden pipe through a bath of molten tin, but in each case has been found unsuccessful. The tin has washed off after a short use in consequence of its not having thoroughly united with the lead.

DURING the last twelve months the large chimney at the Goole Alum and Smelting Co.'s works has been subsiding owing to the intense heat from the furnaces, until it became about four feet out of the perpendicular. The chimney, which is a very handsome erection, is about 200 ft. high, consequently in subsiding to such an extent it assumed a very dangerous aspect; and it was only a question of time as to when it would pass the centre of gravity and fall. Mr J. Berger Spence determined a short time ago to bring the chimney back again to its original position, by cutting out a layer of bricks, about two-thirds of the way round, and about twenty feet from the base. When this layer of bricks had been taken out, strong iron wedges were introduced, and a thin layer of bricks put in the place of the course of bricks extracted. When this had been accomplished, the wedges were then drawn out, and the stupendous structure came over with crushing weight on to the new made bed, assuming its original position. The plan which has been adopted, although very dangerous, has proved perfectly successful, and the calculations have been made with such nicety that no one can detect a single flaw in the chimney.

RELATIVE PURITY OF AIR.—In the annual report of Dr. Angus Smith, the Inspector under the Alkali Act, there are some results of his analysis of air which are worth recording. He remarks that although the estimation of oxygen and carbonic acid in various atmospheres may be used to teach us much, and the mode of analysis is very exact, there are still a few points requiring elucidation. If, for example, some of the oxygen existed in a state of condensation, the amount combining with hydrogen would appear as a greater percentage on the whole than if it existed as oxygen gas. It is abundantly established that air does differ in the amount of oxygen, but the differences are very small in appearance when stated in percentages, the streets of London being almost as pure apparently as the hills of Scotland. The percentages of oxygen and of carbonic acid respectively in the air in various places and under various conditions are shown in the subjoined table:

OXYGEN.	Per cent.
N. E. sea shore and open heath (Scotland)	20.9990
Tops of hills (Scotland)	20.9800
In the suburb of Manchester in wet weather	20.9800
In the suburb of Manchester in wet weather	20.9600
St. John's, Antigua	20.9500
In the outer circle of Manchester, not raining	20.9470
Low parts of Perth	20.9350
Swampy places, favorable weather, France and Switzerland	20.9220 to 20.9500
In fog and frost in Manchester	20 9100
London, open places, summer	20.9500
In a sitting-room which felt close, but not excessively so	20.8900
In a small room with petroleum lamp	20.8400
Ditto, after 6 hours	20 8300
Pit of theatre, 11.30 P. M.	20.7400
Gallery, 10.30 P. M.	20 8600
About backs of houses and closets	20.7000

In large cavities in metalliferous mines (average of many)	20.7700
In currents in metalliferous mines (average of many)	20 6500
Court of Queen's Bench, Feb. 2, 1866	20.6500
Under shafts in metalliferous mines (average of many)	20.4240
In sumps or pits in a mine	20.1400
When candles go out	18.5000
The worst specimen yet examined in a mine	18.2700
Very difficult to remain in for many minutes	17.2000

CARBONIC ACID.

In mines—largest amount found in Cornwall	2.5000
Average of 339 analyses	.7850
In theatres, worst parts, as much as	.3200
In workshops, down to	.3000
About middens	.0774
During fogs in Manchester	.0679
Manchester streets, ordinary weather	.0103
Where fields begin	.0369
On the Thames at London	.0343
In the London parks and open places	.0301
In the streets	.0380
On hills in Scotland from 1000 to 4405 ft. high	.0332
At the bottom of the same hills	.0341
Hills below 1000 ft	.0337
Hills between 1000 and 2000 ft	.0334
Hills between 2000 and 3000 ft	.0332
Hills above 3000 ft	.0336

THE MARVEL OF STEAM ENGINEERING.—This little machine, which is a rotary steam engine, certainly combines the maximum of power in the minimum of space, and seems likely to go far toward superseding the piston engine. Thus, for economy of space, we have an eight-horse engine with governor attached; the entire engine, enclosed within a circular case, 28 in diameter by 2 in. wide, and looking not unlike an ordinary grindstone when hung in a frame. The principle upon which the invention is based is the same as that involved in the turbine water wheel, with the essential difference, however, that the engine consists of two wheels within one case, rotating in opposite directions with equal force and speed—one, the outer wheel, being driven by the direct action of steam upon buckets extending around the inside surface of its rim, and the other by the reactive force of the steam which escapes from two tubular radial arms, bent and flattened at their ends, from which the steam is discharged. This latter wheel has a hollow journal, connected with the supply steam pipe by a stationary steam-tight sleeve, through which the steam is led to the hollow axle or journal of the wheel. These wheels, therefore, have equal velocity and power, and each has a pulley attached, from whence belts are carried to the counter shaft, one of the belts being reversed or crossed. The advantages of this ingenious piece of mechanism are numerous: It costs but one half the price of a piston engine; economy of space, and weight, a thirty-horse engine weighing but 800 lbs.; simplicity of construction, having no valves, eccentrics, cut-offs, or connecting rods; and, moreover, that no engineer is required to run it, any one competent to fire and watch a boiler being sufficient. For farm labor, hoisting purposes, drilling, factory uses, etc., this engine must become valuable, and a very slight adaptation of boiler, with the consumption of the exhaust steam, to avoid noise, would make it a most valuable motor for our city railway cars. The specimen visited was certainly not larger than an ordinary circular cheese, and was yet driving a fan blower and a circular saw of 30 in. diameter, with power to spare. Although not an entirely new invention, having been in use for two years, it is well worthy of notice, and to many of your readers would be a valuable and economical addition to the workshop.

WITHIN the past few weeks there has been a discovery of bismuth in the deepest part of the Crown lode at Botallack. This mineral, by its quality of imparting hardness, is useful in the formation of several alloys. It is used (or ought to be) in type, pewter, Newton's metal, solder, and largely for electro-types. The present "find" was worth from 12s. to 14s. per lb. when smelted, and most of it was rich stuff, and is only a little bunch. The late Mr. Joseph Carne, in a paper which, up to that date, was exhaustive of the productions of St. Just, records that native bismuth had been found in two of the tin and copper lodes of Botallack, up to 1822, but that the best of the specimens for the mineralogist's cabinet had ceased, and only inferior ones were at that time discovered. The present specimens agree with Mr. Carne's description of the auriferous sulphuret of bismuth, then as now found in the Crown lode. The miners of half a century ago, as a few weeks since, ascertained the presence of the metal by thrusting the mineral into an ordinary fire, when it oozed out in small globules.

NILS ERICSON.—The Swedish "Aftonbladet" of the 8th inst. contains the following notice of the celebrated Swedish engineer, Nils Ericson:—"With this great constructor of canals and railways, Sweden has lost not only its greatest engineer, but also one of its best men in every respect. Nils Ericson has written his name in the history of civilization of Sweden, and as long as an engine runs through the valleys of Sweden, and as long as a vessel safely passes the wild water-falls of Trollhattan, his name will be kept in grateful remembrance. His father was Olaf Ericson, an ironmaster at Langbanshyttan, in Wermland, who had two sons—Nils, born in 1802, and his brother John, in 1803, both of whom have done so much credit to their country. Nils, as an administrator and constructor of canals and railways, John, still living in America, and well known through his many inventions in mechanics and naval architecture. John Ericson's greatest engineering works are the Swedish Government railways construction, the reconstruction of Trollhatta Canal, the Dachs at Stockholm, and the Canal Saima in Finland.

EXPLOSIVE COMPOUNDS.—Mr. A Nobel, a Parisian engineer, has taken a patent for improvements in the composition and fabrication of explosive compounds for mines. It is to be hoped that some day means may be found to utilize without too much danger the terrible power of nitro-glycerine. The success which has been achieved with steam which caused at the outset such deplorable accidents, aids the hope to a certain extent. Mr. Nobel seems to have made an important step in the right direction as regards the use of nitro-glycerine for mines. The following shows the composition of two types of his powder: (1.) 68 parts of pulverized nitrate of barytes, 12 of

charcoal, of light texture ; 20 of nitro-glycerine.—(2.) 70 parts of barytes, as above ; 10 of powdered resin ; 20 of nitro-glycerine. The charcoal should be carbonized at a low temperature, and, consequently still containing hydrogen. An addition of 5 to 8 per cent of sulphur to either of the above mixtures gives a powder which fires more briskly, but, at the same time, it increases the danger in the manufacture, carriage, and application of the powder, which should not be lost sight of. The method of using these powders is to place them in cartridges like firework cases, covering the powder with a little fulminant, such as mercury for example, before closing and priming. The cartridge has merely to be placed in the hole, and covered in the usual manner, and it may be fired either by a fuse or the electric spark ; in either case the fulminating powder, acting on the nitro-glycerine, inflames the whole of the contents instantaneously. To render carriage of the cartridges less dangerous, a little ordinary gunpowder may be substituted for the mercurial fulminant.

THE "INSTRUMENT ROOM" OF THE ELECTRIC TELEGRAPH.—In this room, the most sensitive spot in the whole world—the cerebrum which receives and transmits intelligence from all quarters of the globe—may be looked upon as one of the most curious sights in the metropolis. Although hundreds of minds are simultaneously conversing, some with tongues of steel, some with the clear sound of the bell, some again by means of piano-like notes, which spell the words letter by letter although we have the clatter of all these sounds mixed with the metallic tinkle of the electric bell, hailing from distant western and northern cities—not a human voice is heard—although, stranger still, the manipulators are all women. According to the rules of the service, the swifter they talk the better; but it must be done in silence with some unseen correspondent at the extremity, it may be, of the kingdom—a necessary condition in order to insure attention and accuracy whilst the operators are at work. It is certainly no unpleasant sight to see these young women doing the work of the world, proving that they are capable of thoughtful labor, and trustworthy in circumstances of great pith and moment. It is discovered at last that the sewing needle is not the only instrument they can master. They are evidently drawn from the middle rank of life ; and we are informed that they make capital manipulators, the delicacy of their fingers seeming to point out to them the telegraph instrument as a suitable means of employment.

Whilst the visitor is listening to the clatter of one half of the world talking to the other half, he is aware of a dull thud striking from time to time upon the ear. On inquiry, he finds this strange sound proceeds from the pneumatic tube, the new servant the electric telegraph has called to its aid ; and within a glass case against the wall he sees trained just like so many fruit trees in an orchard house, long tubes of gutta-percha, ending in an oblong shaped mouth, covered with thick plate-glass. As he is watching, a long round pellet is projected into this reception case with the force of a spent shot, taken out by the clerk in attendance, and immediately opened. It contains a telegraphic message, sent here for transmission to some other wire. This pneumatic tube at present is only extended to offices half a mile round but as this half mile is in the busiest part of the city, an area in which it is difficult to get along fast by foot passengers, porterage work is done in seconds as compared to minutes by this fleet mechanical messenger. Eventually all the great district post-offices will be connected with the central office by pneumatic tubes, thus vastly accelerating the speed of the telegrams. In addition to the offices within half a mile of Telegraph street, which are thus served by this aerial Mercury, the head office at St. Martin's-le-Grand is provided with a tube. The great submarine cables such as the Atlantic, the Indian, and all the marine lines wishing to use the central office as a means of forwarding messages, will have lines of tube to this room for that purpose. If the reader remembers his old pea-shooter days, he will understand their principle of action in a moment. If he blows he impels the pea, if he sucks he draws it up into his mouth. Pressure and suction are the two forces used in this pea or message-shooter of our maturer days. The telegraph message comes in a round plug-box, covered with carpet or flannel, so as just to make it fit loosely the tube. The suction and propulsive power lies in the depths of the establishment, in the shape of a steam engine.—*Edinburgh Review.*

THE TEMPERATURE of the past summer months has attracted so much attention to the thermometer, that we presume the following summary, from the observations of Prof. Morris, of this city, will not be wanting in interest.

The average temperature of June was 3.54 deg. higher than the mean average of the past ten years, but was slightly below the average of either June, 1860 or June, 1865.

The average for July, was 2.09 deg above the average of the last decade but was below the averages of the same month, 1864, 1865, or 1866. In the latter year, July was nearly a whole deg. hotter (0.85 deg.) than the average given above.

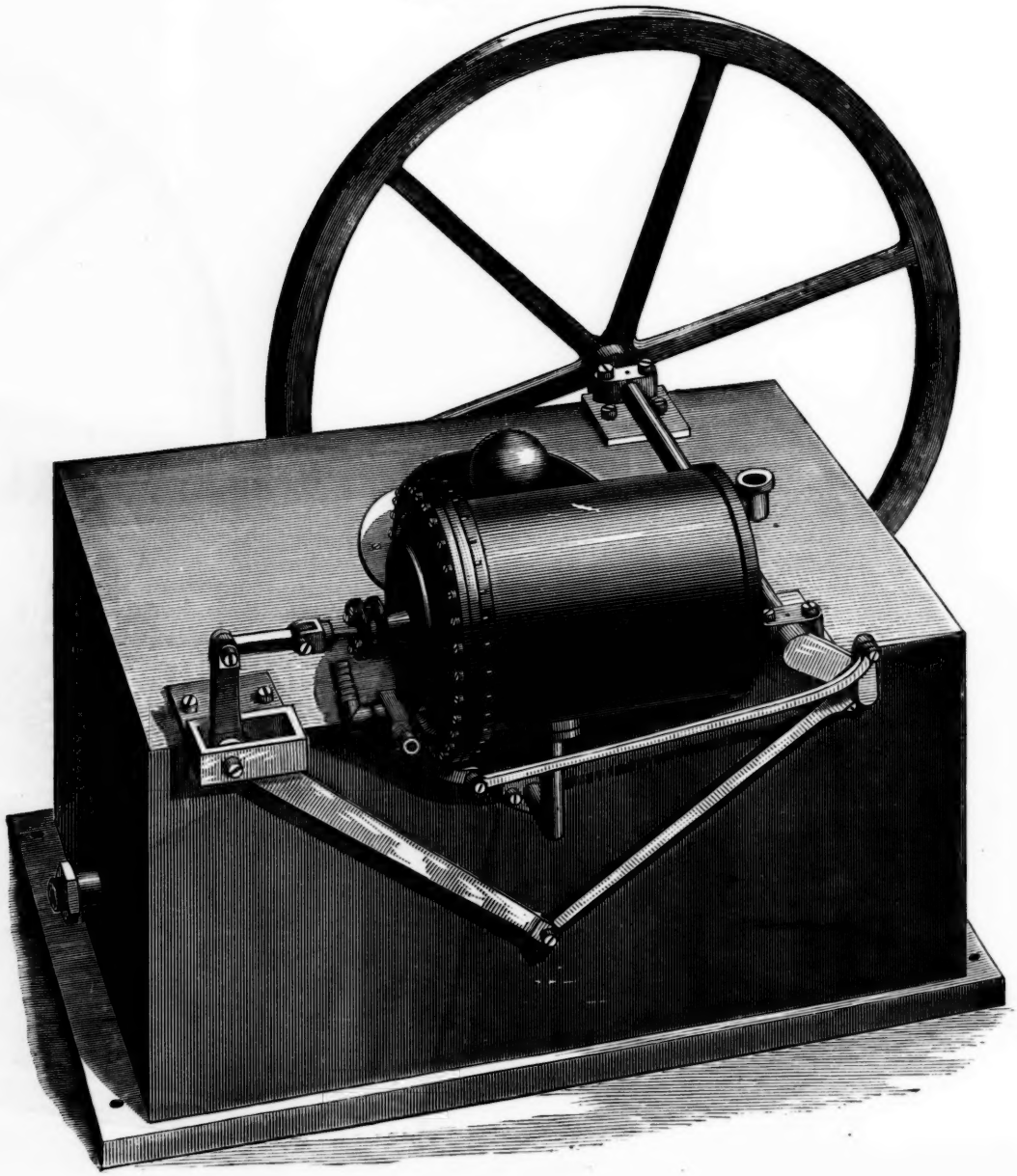
August was 2 82 deg. above the ten year average, but was below the temperature of the same month of 1863 or 1864. In both of these years, August was 3.1 deg higher.

The average temperature of the summer of 1870, was 76.434 deg. Of the last ten years, two summers have been warmer ; the average of 1864 having been 76.936 deg., and that of 186 , 77.396 deg. The popular judgment, however is to some extent justified by the tables which show our last summer was 3.9 deg. warmer than the mean for ten years. It was also 3.78 deg. above the mean of the last quarter of a century.

The extremes among the averages for 25 years were 77.396 deg. in 1865, and 70.064 deg. in 1849.

M. E. DUCHEMIR has sent to the Academie des Sciences the description of a marine battery, which, when plunged in the sea, gives off large quantities of electricity. It is a modification of the electrical buoy tried at Cherbourg.

WHAT is considered as an improved alloy for stereotyping purposes, on account of its ready fusibility and greater hardness than that usually made with bismuth, is composed of 50 parts of lead, 36 of tin, and 225 of cadmium.

Captain Ericsson's Solar Engine.

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